INDEX

TO THE

EXECUTIVE DOCUMENTS

OF THE

HOUSE OF REPRESENTATIVES

FOR THE

THIRD SESSION OF THE FORTY-SIXTH CONGRESS,

1880-'81.

IN 30 VOLUMES.

VOLUME 4.—Engineers, No. 1, part 2, volume 2, part 2.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1881.

INDEX TO HOUSE EXECUTIVE DOCUMENTS.

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REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE THIRD SESSION OF THE FORTY-SIXTH CONGRESS

IN FOUR VOLUMES.

VOLUME II.

PART 2.

WASHINGTON:
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1880.

APPENDIX K.

IMPROVEMENT OF THE HARBORS OF MOBILE, ALABAMA, AND OF PENSACOLA AND CEDAR KEYS, FLORIDA, OF TAMPA BAY AND APALACHICOLA BAY, FLORIDA, AND OF CERTAIN RIVERS IN GEORGIA, ALABAMA, FLORIDA, AND MISSISSIPPI EMPTYING INTO THE GULF OF MEXICO

REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, BVT. MAJOR, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., August 16, 1880.

GENERAL: I have the honor to transmit herewith annual reports for the year 1879–'80, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

K 1.

IMPROVEMENT OF THE HARBOR AT MOBILE, ALABAMA.

As early as 1826 Congress made an appropriation for this work, and from that date until 1857 a total of $228,830.60 had been appropriated. The records in this office do not show how much of this sum was expended. The work done was the dredging of a channel 200 feet wide and 10 feet deep through Choctaw Pass Bar, and the partial dredging of a channel through Dog River Bar 10 feet deep (width not known). The former cut had shoaled to 7½ feet up to 1860, while the latter was found unchanged. In 1870 it was found that a narrow channel of 7½ feet depth still existed through Choctaw Pass Bar, and that portions of Dog River Bar Channel had shoaled to 8½ feet.

Under an appropriation of $50,000 made by act of Congress approved July 11, 1870, for this improvement, dredging operations through these bars were resumed in the fall of the same year, and continued until September, 1876, under a total of appropriations of $401,000 to that date. This amount was entirely expended, and with it, by dredging, a channel has been opened 13 feet deep at mean low-water from Mobile to the 13-foot curve in the bay, with a width of 300 feet through Choctaw Pass Bar, and of 200 feet through Dog River Bar, and to the close of the present year this channel has retained its original depth. A statement furnished me by the pilots shows that twenty vessels, drawing between 13 and 14 feet, have passed through it during the past season.

By act of Congress approved June 18, 1878, the sum of $10,000 was appropriated to be applied to making tests, surveys, and borings,

o determine whether the ship channel now leading from the lower anchorage in Mobile Bay can be deepened so as to admit vessels drawing 22 feet, or any less draught above 13 feet, to the wharves of the city of Mobile.

Under this appropriation, after necessary preparations, field work was commenced in August and continued until the close of the last fiscal year, but on account of unfavorable weather could not be completed. By January 1, 1879, the work had far enough advanced to enable me to make a preliminary report, which was forwarded January 7, and is contained in Ex. Doc. No. 38, Forty-third Congress, and by act of Congress approved March 3, 1879, an appropriation of $100,000 was made for deepening the channel up the bay to 17 feet.

At the beginning of the present fiscal year the surveying party engaged in the survey of this bay continued their work by taking soundings, making borings, and extending the survey to the outer bar, and completed their labors in August, 1879, when final reports, maps, &c., were commenced.

On October 14, 1879, a final report, with plans and estimates for obtaining a channel of 17 feet and of 22 feet depth, submitting several projects for contemplated improvements, were forwarded to the Chief of Engineers. This report, as well as my preliminary report of 1879, were submitted by the Chief of Engineers to the Board of Engineers for Fortifications and for River and Harbor Improvements for consideration. By letter dated February 4, 1880, the Board of Engineers requested to be furnished with additional information in regard to the work, which was forwarded by letter of March 4, 1880.

By letter dated March 26, a copy of the report of the Board of Engineers was transmitted to me, with the recommendation of the Chief of Engineers, approved by the Secretary of War, that the appropriation made by the river and harbor act of March 3, 1879, for improving Mobile Harbor to secure a 17-foot channel, be applied to the 17-foot channel recommended by the Board of Engineers. In accordance with instructions contained in the same letter, the following project for the prosecution of this work during the next fiscal year was submitted by letter of March 3, 1880, viz: Dredging the present channel to a depth of 17 feet and a width of 200 feet throughout its entire length, and an experimental cut 22 feet deep, 100 feet wide, and 300 feet long, on Dog River Bar; that the work be done by contract, if after due advertisement satisfactory bids could be obtained. By letter dated April 3, 1880, this project was approved, with instructions to advertise for proposals. Advertisements were published under date of April 17, and on May 20, 1880, five bids were received, which, with abstract of bids (copy of which is attached), were forwarded to the Chief of Engineers by letter dated May 21.

These proposals being deemed unreasonably high, the Chief of Engineers, by letter dated May 31, authorized the rejection of all bids and the suspension of further action in the matter until after the passage of the river and harbor bill pending before Congress. By act of Congress approved June 14, 1880, an appropriation of $125,000 was made for the fiscal year ending June 30, 1881, and the following project for the expenditure of this and the former appropriation of $100,000 for improving Mobile Harbor, to secure a 17-foot channel, according to the plan recommended by the Board of Engineers, the Chief of Engineers, and approved by the honorable Secretary of War, viz:

Dredging the present channel to a depth of 17 feet and a width of 200 feet the entire length, and an experimental cut 22 feet deep and 100 feet

wide and 300 feet long on Dog River Bar; to advertise for bids for dredging 1,200,000 cubic yards, more or less, or until the appropriations of $225,000 are exhausted, and if a satisfactory bid be received, that the work be done by contract, otherwise such dredging machinery and outfit as may be hereafter approved as the best adapted for the work be purchased, and the work carried on under the immediate direction of this office.

The appropriation of $500,000 asked for for the fiscal year ending June 30, 1882, it is proposed to expend in continuing and completing the work of dredging a 17-foot channel 200 feet wide from the lower bay to the wharves at Mobile.

The estimated cost for the completion of this improvement is	$820,000 00
Appropriations now available	225,000 00
Amount required for completion	595,000 00

As to the permanency of this improvement when completed, or the probable cost of maintaining the depth contemplated, no definite opinion can be formed until the larger portion of the work has been completed.

An appropriation of $500,000 is asked for for the fiscal year ending June 30, 1882, which could be profitably expended in completing the 17-foot channel, 200 feet wide, from Mobile to the lower bay. The statistics furnished me by the collector of the port, given below, will show the present commerce of Mobile; 352,391 bales of cotton were received during the year. As to the probable increase of the commerce of this place upon the completion of a deep-water channel, I would respectfully refer to my final report, published in Ex. Doc. No. 64, Forty-sixth Congress, second session, page 8.

This work is situated in the collection district of Mobile, and Mobile is the port of entry.

The following statistics have been furnished me by the collector for fiscal year ending June 30, 1880:

COMMERCIAL STATISTICS.

	Vessels.	Tonnage.
Coastwise arrivals	87	24,925
Coastwise clearances	54	18,686
American vessels entered	68	22,075
Foreign vessels entered	62	40,422
American vessels cleared	85	23,930
Foreign vessels cleared	71	35,949

Value of domestic exports to foreign countries from Mobile, for fiscal year ending June 30, 1880	$7,187,975 00
Value of imports of foreign goods port of Mobile, for the fiscal year ending June 30, 1880	430,297 00
Total amount of revenue collected at port of Mobile, for fiscal year ending June 30, 1880	63,946 09

Money statement.

July 1, 1879, amount available	$102,770 62	
Amount appropriated by act approved June 14, 1880	125,000 00	
		$227,770 62
July 1, 1880, amount expended during fiscal year		2,886 62
July 1, 1880, amount available		224,884 00
Amount (estimated) required for completion of existing project		$595,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		500,000 00

Abstract of bids received and opened May 20, 1880, for dredging in Mobile Harbor, Ala.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	James E. Slaughter	$0 26.9	October 15, 1880	October 15, 1881.
2	S. N. Kimball	25	Three months after execution of contract.	One year from date of commencement of work.
3	George C. Fobes & Co.	24.9	Ninety days after signing contract.	One year from date of commencement.
4	Charles Fitzsimons	30	Not given	Not given.
5	J. W. Rumsey	27	do	Do.

SURVEY OF MOBILE HARBOR, ALABAMA, WITH REGARD TO ITS FURTHER IMPROVEMENT.

The act approved June 18, 1878, directed the amount appropriated, $10,000, to be applied to making tests, surveys, and borings to determine whether the ship channel now leading from the lower anchorage in Mobile Bay can be deepened so as to admit vessels drawing 22 feet or any less draught above 13 feet to the wharves of the city of Mobile.

Preparatory work was commenced, under this act, on the 12th of July, 1878, and the field work on the 15th of August. A preliminary report was made on the 7th of January, 1879, which is contained in Senate Ex. Doc. No. 38, Forty-fifth Congress, third session. The work was terminated on the 1st of September, 1879, and the final report commenced.

During this time, in addition to the labor of collecting outfit and organizing, soundings were made from a point in Mobile River opposite Beauregard street, near the upper limit of the city of Mobile, down the river, and through the channel dredged under Congressional appropriations from 1871 to 1877; also throughout Garrow's Bend (just below Choctaw Point) and down the western shore of the bay to Alabama Port (the nearest point on the mainland to deep water); thence to the 18-foot curve in the lower anchorage; across the upper end of the bay, across the lower end or entrance, and at various other points.

Borings were made, at intervals of 2,000 feet, from a point in Mobile River opposite Government street, near the center of the city front, down the present channel, beyond Dog River Bar, and from there, at intervals of a mile, about, to the 18-foot curve at the lower anchorage, a distance (total) of about 27 miles. Other borings were made along the western shore. All of them were made to a depth of 26 feet. A line of levels was run from Cedar Point (the extreme southern point of the western mainland) up to the Mobile and Montgomery Railroad Bridge, across Mobile River (above the city), a distance of about 46 miles.

Triangulation was carried over the entrance of Mobile Bay, including Coffee, Dixie, Sand, and Pelican islands, east end of Dauphin Island, and Mobile Point, over that portion of the bay included between the eastern and western shores, the obstructions on the south, and the mouths of the Mobile, Tensas, Spanish, Apalachee, and Blakeley rivers on the north, and throughout the whole length of the Mobile River.

Cross-sections and current observations were taken of all the above rivers, and of all their important tributaries, inlets, and outlets, where practicable.

Samples of water were obtained at various times, localities, and depths, in rivers and bay, and tested for sediment.

The usual office-work, plotting notes, arrangements and study of data, consumed the remainder of the time.

The results obtained from the work are as follows:

The tide-gauge observations indicated a total average rise and fall of 3 feet in the bay; that the tidal current tends towards the eastern shore, the river discharge being principally carried along the western shore. (As further evidence of this, the eastern shore is comparatively free from, while the western is covered with, accumulations of drift from the rivers.)

At the cut-off in the Alabama River, about 70 miles above the head of the bay, tidal observations indicated a rise of 0.77 foot.

The soundings showed that the old dredged channel has maintained the depth obtained in 1877, and that there is now a good channel of 13 feet depth way through.

The following is a list of vessels drawing 13 feet and over that arrived at and departed from Mobile during ten months, without meeting any difficulty in the cut, with the high tides for the corresponding dates, as indicated by the tide gauges, the average mean low-tide reading being 7′ 2″:

Date.		Name of vessel.	Draught.		Average high-tide.	
			Feet.	*In.*	*Feet.*	*In.*
1878.						
Sept.	15	Schooner Mary J. Cook	13	0	7	00
	18	Ship Kate Davenport	13	6	7	30
	22	Schooner Normanda	13	6	8	40
Oct.	6	Brig Emily T. Sheldon	13	0	8	20
	16	Ship Ludwing Heyen	13	0	8	30
	28	Bark Alfred	13	0	7	90
Nov.	10	Bark Henry Norwell	13	0	7	65
	15	Brig John D. Tupper	13	0	7	75
	19	Bark Jens Brandi	13	0	7	45
	25	Bark Prim	13	0	6	85
Dec.	9	Schooner Annie S. Connent	13	0	8	30
	23	Bark Christiana	13	0	6	70
1879.						
Jan.	7	Brig Afton	13	0	6	10
	27	Brig Gemma	13	0	7	55
Feb.	3	Brig Detmar	13	0	7	30
	4	Brig Meta	13	0	7	35
	5	Bark Eidsiva	13	0	7	50
	8	Schooner Annas	13	0	6	50
	10	Bark Yruchulo	13	0	7	35
	16	Bark Ephraim Williams	13	0	8	00
	25	Bark Welaka	13	0	8	05
Mar.	9	Bark Medlor	13	0	7	30
	13	Schooner L. P. Whitmore	13	0	8	30
	22	Bark Zeulima	13	6	8	40
	23	Bark Crescent	13	0	7	30
May	9	Schooner Rennie Carleton	13	6	8	30
	11	Bark Hans Thies	13	0	8	00
June	4	Brig Pacific	13	0	8	10
	4	Schooner Geo. W. Tochenow	14	0	8	10

The banks of the cut were also found generally unchanged.

The water in Mobile River, below Beauregard street, has about the same depth for navigable purposes as in 1871, except at its mouth, where the depth appears to be increasing on the east bank, at Pinto Point, and decreasing on the west bank, at Choctaw Point, outside of the dredged channel, however. In Garrow's Bend the water is shoaling rapidly in toward the shore, probably caused by the jetties constructed by State authority there in 1872. Generally speaking, no material changes were found in the body of the bay. The borings everywhere indicated about the same condition of the bottom for the same depths. Sand mixed with mud and shells to a depth of about 14 feet, and below this to the depth of 26 feet, the extent of the borings, a stiff tenacious clay, hard on top and softer below. The same formation was found on the bluff banks of the western shore, the clay being from 12 to 15 feet from the

surface or about the water level. The line of levels indicated a fall of only 0.75 of a foot in 46 miles.

The principal features shown by the triangulation are the extensive changes that have taken place since 1856, the date of the last Coast Survey chart; 1st, at the entrance of the bay in the formation of the two islands, "Coffee" and "Dixie," to the east of Sand Island, and on the opposite side of the main ship-channel, the change in form and extent of Sand Island, the large diminution in area of Pelican Island, the washing away of the northerly beaches of Dauphin Island and Mobile Point, and the deposit on the corresponding south beaches.

2d. At the head of the bay in the extension of the river mouths and their bars to the southward. The cross-sections and current observations indicate an aggregate discharge of over 100,000 cubic feet per second by the rivers into the bay.

The sediment observations gives 100 grains of sediment to the cubic foot of water as the average amount in the rivers, and decomposed vegetable matter as the principal component.

Before stating the conclusions arrived at, or opinion formed, I would state, it was not considered the intent of Congress to restrict the survey to a study of only a single project, although that idea might seem to be conveyed by the wording of the act, and, therefore, all were considered which had at different times been suggested (so far as I could learn) or occurred to me, for the relief of the commerce of this port, as follows:

I. Making a harbor on the south of Dauphin Island and connecting it with Mobile by rail.

II. Making a harbor on the north side of Dauphin Island with railroad connection.

III. Making a harbor at Alabama Port with same connections.

IV. Making a canal inland from Mobile to Alabama Port.

V. Damming all but one river, improving that one, and directing its discharge into the bay with the expectation of its scouring its way to deep water.

VI. Using the tidal current for scouring a channel by training its flow between the entrance and upper end of the bay between paralled walls.

VII. Dredging a channel through the bay, following the line of deepest water, and carrying the dredged material to a safe distance.

VIII. Dredging and scouring a channel through the bay by damming all but one outlet, contracted to a proper width, and training the flow between artificial parallel banks to deep water or tidal channel, and dredging out or stirring up all material that would not scour.

The first four projects are not believed to be desirable by themselves (although the last should, and probably will at some future time, be carried out by private enterprise, and would be of great importance in connection with the work recommended), and this was considered so apparent on account of the evident cost, direct and indirect, in necessary construction and depreciation of values in the present city, that they are passed over with mere mention.

The fifth project would not, in my opinion, prove successful. The sixth, I think, could be carried out to a successful conclusion, but the cost would be very great.

The seventh project is a continuation of the one that has been persistently followed since 1827, by which the water has been deepened from a minimum depth in Choctaw Pass of 5 feet 6 inches, and on Dog River Bar of 8 to 13 feet throughout. The success of this plan so far

proves the sagacity of the various engineers who have advocated it, and I can see no good reason why it cannot be carried still farther, in obtaining still greater depths, and be equally successful.

The eighth project is a combination of the two principal ones which have been continually agitated since 1827.

Each one has had many strong and able believers, who have asserted the superiority of one or the other method, verbally or in print.

The great objection urged, heretofore, against the dredging system has been that a cut made in the middle of a large shoal bay, receiving annually from its tributaries immense quantities of sediment, and traversed by a complicated system of river and tidal currents, due to winds, tides, and river discharges, would rapidly fill up. This argument has been disproved by the facts to the present time.

The principal objections to the scouring system, or combined scouring and dredging, has been the great cost of training the flow of river water through the bay a sufficient distance to accomplish the desired result, the perishable nature of such training-walls, if built of such materials as could be obtained at a reasonable expenditure, and the probable formation of a bar at the ends of the dikes or jetties.

As the scouring power of the large volume of water daily discharged by the various rivers into Mobile Bay seemed generally to be recognized by all engineers who have written or expressed opinions in the matter, a portion of the time consumed in the survey was devoted, and a great deal of study given, to ascertain if there was any way to utilize this force that would be free from the objections mentioned, with results as follows:

The river water can be all emptied into Mobile Bay through one mouth of proper cross-section at Choctaw Point, either by damming all outlets but Mobile River, at their heads or at their mouths, at a comparatively small cost. Thence through the bay parallel walls would have to be constructed to near a point where the tidal current sweeping by their ends would be strong enough to prevent the formation of a bar. There is such a point, and, therefore, the last objection has no weight. To reduce the force of the others, it is suggested they might be built of brush and piles, of which there is an unlimited supply, of easy access, along the whole length of the western shore below Dog River Point, to be covered first with material excavated from the bottom with a dredge-boat, and afterwards in the more exposed parts with stone ballast from vessels arriving, or from quarries up the river, and that the channel be carried so near the western shore that but one strong dike need be built of the full extent; the length of the other being materially reduced by the portion of the western shore which might be utilized, and the cost of such as had to be built reduced to a minimum, by the fact that as it would not be exposed to rough water a simple inexpensive construction would answer.

The amount that would be removed by scour, and the amount that would have to be dredged after the construction of the training-walls, I am not prepared to answer, although I am clearly of the opinion that the matter is worthy of consideration, and even of experiments, if necessary, before undertaking the further improvement of Mobile Bay. As the character of the improvement and the amount that can be profitably expended on it depends upon the commerce, present and prospective, that is to be provided for, such reliable information as I have been able to obtain is here given as to the former and facts and opinions regarding the latter. The work is situated in the collection district of Mobile,

and Mobile is the port of entry. Its commercial statistics, as furnished by the collector of customs for the last fiscal year, is as follows:

	Vessels.	Tonnage.
Coastwise arrivals	86	15,981
Coastwise clearances	51	15,073
American vessels entered	82	26,609
Foreign vessels entered	58	36,933
American vessels cleared	64	21,029
Foreign vessels cleared	49	30,888

DOMESTIC EXPORTS.

American vessels	$2,438,793
Foreign vessels	3,781,025
Total	6,219,818

The Mobile Cotton Exchange, in its annual statement dated September 1, 1879, givés a clearer idea of the business of the port, and from it is condensed the table given below:

COTTON RECEIPTS 1878, 1879, AT MOBILE.

	Bales.
Alabama River	41,506
Bigbee River	61,741
Warrior River	26,488
Mobile and Ohio Railroad	138,874
Mobile and Montgomery Railroad	91,977
Wagon	1,822
Total	362,408

Coffee importations, 1879.—Eight cargoes .... 29,725 bags.

NAVAL STORES—RECEIPTS AND VALUES—1878, 1879.

	Barrels.	Values.
Rosin	143,509	$265,492
Turpentine	21,118	232,298
Tar	250	750
Pitch	2,500	6,000

LUMBER, TIMBER, COAL, ETC.—1878, 1879.

Lumber	feet..	11,011,545
Staves		120,052
Shingles		3,682,550
Hewn timber	cubic feet..	245,507
Sawed timber	do....	65,519
Pennsylvania and English coal	tons..	3,352
Alabama coal	do....	3,015
Fish and oysters	value..	$127,900
Vegetables, shipments in 1878, 1879	do....	$168,778
Salt, imported	sacks..	50,520
Wool; received	pounds..	500,000

In this connection perhaps should be mentioned the existence of three cotton and woolen mills in Mobile and vicinity, as showing a fair commencement in an important manufacturing industry, and the organization of a steamship company for the purpose of establishing a line of steamships to ply between Mobile and Liverpool. The first steamer for this line is already under construction.

The country tributary to Mobile should include, it would seem, the

whole Mobile or Alabama River basin, including the greater part of Alabama and a portion of Mississippi and Georgia, to say nothing of possible extension by an enterprising use of railroads already built and commenced, and canals already surveyed for.

The Alabama basin contains approximately 33,000 square miles. The annual average rainfall is given by the Signal Service records as $4\frac{1}{2}$ feet, making over the whole basin about 28 cubic miles of water. This mass of water, after meeting with the usual losses from evaporation, &c., flows through the Oostenaula and Etowah, Coosa, and Tallapoosa, Little Tombigbee, Sipsey, and Black Warrior, Tombigbee, and Alabama, and other minor streams into the Mobile, which carries all the water in a single stream for about 5 miles, with an average width of 1,050 feet and depth of $39\frac{5}{10}$ feet; it then divides and subdivides, finally discharging into Mobile Bay an aggregate of about 100,000 cubic feet per second, through five mouths, the Blakeley, Appalachee, Tensas, Spanish, and Mobile forming a delta containing about 250 square miles, 186 of which (about) is heavily timbered, the balance being marshy.

The river discharge then passes through Mobile Bay, which has an area of about 375 square miles, and finally reaches the open Gulf through three outlets, the main one between Sand Island and Dixie and Coffee, the others being between Coffee and Dixie and Mobile Point, and between Dauphin Island and Sand Island. There is still another outlet into Mississippi Sound, between Dauphin Island and Cedar Point.

The rivers mentioned draining this basin are all navigable, or susceptible of improvement, so as to be made navigable, a total length of over 1,500 miles, reaching and passing through a country which has a capacity for producing over 1,000,000 bales of cotton; supplies of coal and iron that will compare favorably in character and extent with those of any other section of this country; building material, as granite, marble, gneiss, limestone (and various other mineral elements of wealth), and lumber. All these are accessible to water transportation by the river routes previously referred to, and when the improvements already in progress are completed coal should be delivered in Mobile at a cost of \$2 per ton, and the other articles at sufficiently low rates to allow of successful competition with any other port on the Gulf of Mexico.

In fact, though the Mobile Basin is insignificant when compared with that of the Mississippi, it is so merely on account of its inferior size, and I question whether there is any continuous area of the Mississippi Valley, of the same extent, that has been so bountifully supplied by the Almighty with the elements of wealth and progress. It is, in my opinion, to be as important a factor in the future of the country as any continuous 1,500 miles of the Mississippi River or its navigable tributaries, with the adjacent country.

The cost of all the improvements required to develop the resources of this basin, it is believed, will be considerably less than that expended by Pennsylvania in water routes from the mines in Philadelphia.

Mobile, a city at present of about 40,000 inhabitants, is situated at the junction of the river system with Mobile Bay, on the west bank, only 27 miles from a good channel of least depth of 22 feet, and only 36 miles from the deep water in the open gulf.

Its growth has been continuous, though spasmodic, since its settlement on the present site in 1711.

It has a railroad system already completed, giving competitive routes with the rivers to the lumber, cotton, coal, and iron.

With the present commerce, therefore, as a basis, and the resources and transportation referred to and a deep channel to the sea, there is more

than an ordinary probability that the commerce of the port would in a few years be increased at least 100,000 bales of cotton, 1,000,000 tons of coal, 10,000,000 cubic feet of lumber (lumber is now being towed, and transported by rail from Mobile Bay to Pensacola for shipment).

In view of the large commerce present and prospective, and the fact that the development of the lumber trade depends for its greatest success upon as deep a channel as possible, I think no project should be adopted looking to a less depth than 21 feet at mean low-tide, which at presents exists on the outer bar.

The particular method of improvement should, in my opinion, be, as already suggested, either by dredging a channel of sufficient depth and width from the river to the anchorage, following the line of deepest water and carrying the dredged material to a distance, or to confine the entire river discharge to a single channel through the bay, to a point where the tidal current sweeping in and out of Mobile Bay is sufficiently strong to carry away any sediment brought down by the river current, and dredging out any material that might not be removed by the scouring power of the water.

In this connection it should be borne in mind that the amount of tidal water which passes from the Gulf into the bay, and back into the Gulf, every twenty-four hours with the ebb and flow of the tide is more than twice as great as that discharged by the rivers, and that the outlet is so contracted that a very deep channel has been formed.

The former has the success of previous work done in the bay in its favor, but the disadvantage of being a narrow channel, in the middle of a wide bay, exposed to cross winds and currents, making its navigation difficult at times, and rendering it possible that large expenditures might be required at some future time to remove deposits that might take place.

The latter would have the apparent advantage of turning 24 miles of bay into river navigation—allowing rafts of lumber, or barges of coal, iron, or any such product, to proceed to the lower end, and meet sailing vessels at Alabama Port, within 15 miles of the open Gulf, to which point they could sail—of positive permanency when once fully accomplished, and possibly of greater economy in the end, if the construction of the necessary dams, dikes, and shore jetties will cause the current to do most of the work of excavation; a reasonable supposition, I think, as a glance at the map shows that the river has built its own banks, and scoured out between down a distance of over 40 miles of delta, and is now opening its way in the same manner down the bay at an average rate for the past 13 years of over 100 feet per annum, through 5 outlets, using its sediment to build banks for each, which in turn confine the water to produce the scour.

If, however, the river water would not scour with the rapidity or to the extent desirable, the fact remains that still the amount to be dredged would be much less than double the amount required in the other case, whereas the cost should not exceed one-half as much per cubic yard, for the following reasons: On the deep-water line, near the middle of the bay, the material dredged would have to be carried by tugs and scows an average distance of over three miles, for deposit, to prevent its washing back in the cut. On the western shore line, with the dikes, &c., the material would be deposited by the dredges immediately on them or alongside the channel. Again, in the former case, a great deal of time would be lost and damage sustained either by being compelled to suspend work on account of, or by attempting to work in, rough water, whereas, in the other case, the dredge would be working under the pro-

tection of the western shore, on one side, and the dike on the other, or in comparatively smooth water. There is a question also whether a channel inshore, protected by banks on both sides, 100 feet wide would not be better than one 200 feet wide in the middle of the bay without such protection, with a clear reach of 6 miles (average) open water on the sides, to produce rough water and cross currents, and length of 27 miles.

The estimated cost of the work by the first system is as follows:

For a channel with a width of 200 feet and depth of 17 feet:	
Dredging, 4,100,600 cubic yards, at 20 cents per cubic yard	$820,000 00
For a channel of the same width (not considered sufficient, however), and 22 feet deep:	
Dredging 9,900,000 cubic yards, at 20 cents per cubic yard	1,980,000 00

The estimated cost of the other system is as follows:

For a dam across the Apalachee River	$15,000 00
For a training-wall from lower end of east bank of Tensas River to lower bay, 28 miles, at $23,812	666,736 00
Dredging a channel 100 feet wide, 21 feet deep, 24 miles long, 7,509,312 cubic yards, at 15 cents	1,126,396 80
Additional spur-dikes and jetties, 5 miles long, at $10,000	50,000 00
Total	1,858,132 80
Contingencies and superintendence, 10 per cent	185,813 28
Grand total	2,043,946 08

An experiment might possibly be made at a reasonable cost at one of the river mouths that would determine approximately the amount of scour for a given time that might be expected, on which the success or failure of the combined scouring and dredging system depends. In conclusion, I would recommend that the subject be referred to the Board of Engineers for Harbor and River Improvements for their consideration.

There is forwarded herewith—

I. A map of the delta of Mobile River and Bay, of which the parts previously referred to are from the survey made, the rest being a compilation from the best authorities.

II. A map showing work previously accomplished and present condition of channel dredged under former appropriations, and location of proposed improvements for securing a deeper channel.

Skeleton map of Mobile Basin, cross-sections of the various rivers, and tables of current and sediment observations.

Respectfully submitted.

A. N. DAMRELL,
Captain of Engineers.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., March 16, 1880.

SIR: Referring to my letter of the 11th instant, submitting copy of report of Capt. A. N. Damrell, Corps of Engineers, on the survey of the harbor of Mobile, Ala., with a view to its further improvement, provided for in the river and harbor act of June 18, 1878, and, in connection therewith, I beg leave now to submit a copy of report, with accompanying map, from the Board of Engineers for River and Harbor Improvement, to which the report of Captain Damrell was referred for consideration.

As the appropriation of $100,000 made by the river and harbor act of

March 3, 1879, limited the depth of channel to be secured to 17 feet, the views of the Board were also requested upon the proper application of this sum.

It will be perceived that the Board recommends that if 17 feet depth will satisfy the shipping interests of the port, this depth be attained by dredging the present channel. At the same time it presents an approximate estimate of the cost of securing a channel of 22 feet depth, from the lower anchorage of Mobile Bay to Garrow's Bend and to the wharves of the city of Mobile.

I beg leave, therefore, to advise that the application of the appropriation of March 3, 1879, to the 17-foot channel recommended by the Board, be authorized by you, as the channel of that depth is understood to be concurred in by the business interests of Mobile as satisfying the present shipping needs of that port.

I would further suggest that the report of the Board be transmitted to the House of Representatives for the information of the Committee on Commerce in connection with the report of Captain Damrell above referred to.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS
AND FOR RIVER AND HARBOR IMPROVEMENT,
Army Building, New York, February 28, 1880.

GENERAL: The river and harbor act of June 18, 1878, appropriated $10,000 to be applied "to making tests, surveys, and borings to determine whether the ship channel now leading from the lower anchorage in Mobile Bay can be deepened so as to admit vessels drawing 22 feet, or any less draught, above 13 feet, to the wharves of the city of Mobile.

This duty devolved upon Capt. A. N. Damrell, Corps of Engineers, in charge of the improvement of Mobile Harbor and Bay. His preliminary report thereon, made in January, 1879, was followed in October by a full report, with plans and estimates for obtaining a channel of 17 feet, and of 22 feet depth from the fleet anchorage through the bay into Mobile River. These have been sent to this Board by your letter of November 13, 1879, for consideration and report.

The following brief description of the locality in question and notice of the works of improvement connected therewith, as already executed, seem essential to a clear understanding of the problem under consideration. The river Mobile, at the delta formation, has several outlets, two of which, the Tensas and Spanish, unite to pour their waters in one mass into the bay in close vicinity to the mouth of the third outlet, called Mobile River, on which lies the city of Mobile. Along the wharf front of this city the river depth varies (at high-water) from about 19½ to 22 feet, this latter also being the depth over the outer, or sea bar. Lower down at the bend, near Choctaw Point, the depth is rather greater. Just outside of the mouth of this outlet there has always existed a sand-bar, known as Choctaw Bar. Dog River Bar is about 3 miles from the

river mouths, and seems to be formed by sedimentary deposition of the fine material brought down by all the branches of the stream From this bar the bottom of the bay slopes down to the 13-foot curve for a distance of about 6 miles, and thence has a plateau formation of about 15 miles extent, reaching to within 3 miles of the fleet anchorage.

From the most reliable testimony that can be obtained Dog River Bar has not shoaled, nor has the bay, during the past 50 years. No accurate maps of a sufficiently early date exist to establish this point indisputably. The greatest depth of water on Choctaw Bar in 1828–'29 (by verbal testimony) was 5½ feet. During that period it was dredged to give a channel-way of 8 feet, and in 1838–'39 was again deepened to 10 feet, but having been left undisturbed for the succeeding 21 years the bar re-formed so as to give a depth of 7½ feet only in 1860. The excavation to the same depth on Dog River Bar, made in 1854, gave no indication of filling. It thus appears that while Dog River Bar, so called, and the bed of the bay shoal, if at all, so slowly as to be unnoticeable, the excavated channel through Choctaw Bar refilled at an average rate of about 1½ inches a year. In view of the above facts the Board of Engineers that in 1872 considered this question of deepening the channel of approach to the city of Mobile did not think that a permanent improvement, in the strict sense of the term, could be reached. It was their opinion that any channel excavated through Choctaw Bar would require dredging from time to time to keep it open to the depth needed. They nevertheless recommended the trial of dredging to obtain a depth of 13 feet through Choctaw Bar and Dog River Bar southward in the bay to the 13-foot curve. That recommendation has been effectively carried out, the depth of 13 feet being attained during the year 1877. By the testimony of Captain Damrell, who has had charge of this improvement since April, 1873 (see his report of October 14, 1879), there was no evidence of filling either in the channel excavated through Choctaw Bar or in that in the bay beyond the obstructions up to that date—that is, for a period of about two years succeeding the completion of the dredging. It was our opinion, however, that sufficient time has not elapsed to test this question.

The thorough survey of the bay, harbor, and river Mobile by this officer was made under the act before mentioned with a view to obtainig data for further projects of improvement of the channel to the city. After a full study of the results of the survey, aided by an experience of more than 10 years in this locality, Captain Damrell now presents, among several projects mentioned, two with plans and estimates which meet his approval. His preference is evidently given to the second. They are as follows:

First. To dredge "a channel of sufficient depth and width from the river to the anchorage, following the line of deepest water and carrying the dredged material to a distance." Second, "to confine the entire river discharge to a single channel through the bay to a point where the tidal current sweeping in and out of Mobile Bay is sufficiently strong to carry away any sediment brought down by the river current and dredging out any material that might not be removed by the scouring power of the water. In this connection it should be borne in mind that the amount of tidal water which passes from the Gulf into the bay and back into the Gulf every 24 hours with the ebb and flow of the tide is more than twice as great as that discharged by the rivers, and that the outlet is so contracted that a very deep channel has been formed.

"The former has the success of previous work done in the bay in its favor, but the disadvantage of being a narrow channel in the middle of

a wide bay, exposed to cross winds and currents, making its navigation difficult at times, and rendering it possible that large expenditures might be required at some future time to remove deposits that might take place.

"The latter would have the apparent advantage of turning 24 miles of bay into river navigation, * * * of positive permanency when once fully accomplished, and possibly of greater economy in the end if the construction of the necessary dams, dikes, and shore jetties will cause the current to do most of the work of excavation."

His estimates for these projects are:

1st. Dredging channel 200 feet wide:	
17 feet deep	$820,000 00
22 feet deep	1,980,000 00
2d. Construction of training wall:	
Dredging for a depth of 22 feet, &c	2,043,946 08

Our views as to these projects are given in the following brief statement:

If the question were simply to obtain a passage-way to Mobile of but 17 feet depth, we would recommend the deepening the present channel by dredging, the process by which 13 feet has already been reached. The first cost of this method would be, as above stated, about $820,000.

Any other process, to be effective, would involve, besides more or less dredging, the long training wall or walls from the river mouths down the bay to the deep anchorage, with an expenditure probably in excess of $2,000,000, together with the cost of protection against overflow in the vicinity of Mobile and above, due to lengthening the river by transferring its mouth to the fleet anchorage, thus changing its normal slope and backing the water up stream. This point will be more fully set forth in our notice of Captain Damrell's second project.

It is true that a dredged channel cannot be regarded as quite permanent. The causes that formed Choctaw and Dog River bars must still exist. It seems certain, therefore, that small appropriations will be needed from time to time to keep open any channel through Choctaw Bar formed by dredging. But the saving in the original outlay will probably more than compensate for the occasional expenditures.

The question, however, of procuring 22 feet depth of channel by the process of dredging is quite a different one. It will involve an expenditure of about $2,000,000 with a channel 200 feet wide, and $3,000,000 if the width be 300 feet, which width is thought to be necessary for easy navigation for a length of 25 miles in the open bay of Mobile. A project so costly in its execution should not be entered upon without a reasonable promise of permanent results. Now, although past experience, if reports are entirely accurate, indicates that the channel over Dog River Bar did not fill perceptibly from 1854 to 1860, when deepened about 2 feet, and that it has not filled measurably during the past three years, although excavated to an additional depth of 3 feet, we do not think there is sufficient evidence to prove that if the channel be further deepened to 22 feet and lengthened to reach the lower anchorage, it will be entirely permanent. Indeed, we anticipate that the same process that formed Dog River Bar will in time, though by a slow process, reform it where excavated. There can be little doubt that there is some deposit in the bay of light material brought down by the river, and that this channel must get its portion of that deposit. Our experience in reference to Choctaw Bar runs through a much longer period, and proves beyond doubt a tendency to refill any shallow excavation through it. We cannot, therefore, hope to maintain a channel 22 feet deep over this

bar without dredging from time to time. The river along the city front does not maintain that depth; much less must we expect it at the mouth, where the waters are checked by dispersion.

As already stated, prior to 1860 the indications were definite that the mouth of the Mobile branch, when deepened, filled again at the rate of 1¼ inches a year. Captain Damrell states that he discovered no filling for two years preceding his recent survey. It may be that the soundings were not made with that extreme of accuracy that would note a change of 2 or 3 inches. At any rate, if it does not fill, the conditions must be changed. Now, we know that since 1860 pile obstructions on the east have been driven and still exist in such position as to concentrate the united waters of Tensas and Spanish River outlets toward the Mobile outlet, and that this last has been narrowed by similar obstructions, reaching well up towards Choctaw Point. To these obstructions the present greater permanence of depth in Choctaw Pass, if it exist, may be due. But the conditions of the delta are constantly changing, and the mouths are advancing at the rate of about 100 feet a year. If the channel is stable now it may not remain so many years. We are, therefore, forced to the conclusion that the dredging project does not insure that permanency of channel-way which so costly a work ought to secure.

The second project of Captain Damrell extends the eastern bank of the Tensas branch artificially by dikes in a southwesterly direction across the outlets of the Spanish and Mobile branches, and thence in a southerly course to the vicinity of Alabama Port, thus collecting all the waters of the rivers flowing into the bay in one stream between this artificial bank and the western shore, and literally extending Mobile River to the lower anchorage. If the project were feasible it would not be easy to count its cost or foresee the difficulties in the way of its execution. It would create an almost insuperable barrier to navigation until completed, for the reason that the construction should progress from the mouth of the Tensas southward in order to make the river currents do the work of excavation. In what manner this artificial bank should be made and of what material formed to enable it to endure the wash of the waves on the bay side and the rush of waters on the river side, could only be determined experimentally. Its construction, however, would doubtless require to be more solid than the method of the plan submitted. If, to avoid the impediment to navigation, the river outlets into the bay be left open until the east bank of this new channel be built from the vicinity of Choctaw Point to the lower bay, this great disadvantage would result, that the immense mass of material excavated from the bed of this river extension by the current would all be transferred to its outlet, with the chance of forming a bar there and of filling Grant's Pass. In fact, it is a transference of the delta of the Mobile River from the head of the bay down to the islands—a very radical change in the conditions that at present exist at the port of Mobile.

Now the average river discharge is estimated by Captain Damrell to be about 100,000 cubic feet per second, and the discharge from the bay with the falling tides per day twice that amount. By these outflowing waters as well as the inflowing tides the sea bar is maintained at a depth of 22 feet. As the river silt is mostly deposited at the head of the bay, which is advanced thereby at the rate of about 100 feet per year, the exterior or sea bar gets little or no accession therefrom. The conditions, therefore, beyond the entrance-way at Mobile Point are favorable, and it would not be well to inaugurate changes that might disturb them, for it is easier to procure deep water through the inner bar

than it would be through the outer or sea bar, should that commence to shoal by virtue of the transference of the river deposit from the head of the bay to the sea.

A stronger objection to the project is the river extension itself of 24 miles below Mobile, which virtually overthrows its present regimen, changes its slope and surface level at the city and above for many miles. Head to cause the flow from Mobile to the new mouth must be obtained by raising the banks east and west in the vicinity of the city and far above.

The numerical data at hand are not sufficient to decide definitely to what extent the elevation of the present water surface must be carried; but to fix our ideas some approximate computations may be made.

If Captain Damrell's estimate as to the average volume of discharge be correct—viz, 100,000 cubic feet per second—it is safe to assume that the flood volume cannot be less than 200,000. His proposed new channel is 1,400 feet wide, and, admitting that a mean depth of 22 feet will be excavated, the new cross-section will be 30,800 feet, which would involve a mean velocity of 6.5 feet per second, and require a slope of 0.00034 or 1.8 feet per mile.

Now, a slope 1.8 feet per mile would give a rise, going back from the mouth of the extended river to Mobile 24 miles, of 43.2 feet, and this rise would be needed to effect the discharge, provided the bed slope by deposition could maintain itself parallel to the surface. Should, however, the bottom of the river remain undisturbed at its present level, the discharge would be effected by raising the surface waters at Mobile 7.5 feet, the corresponding velocity being 4.82. As the wharves along the city front are but 3½ feet above ordinary high-water, and 1 foot above equinoctial tides, and overflowed during extraordinary gales, it is evident that the above conditions cannot be carried out. It is not necessary, however, that more water than the ordinary discharge, say 100,000 cubic feet per second, should run down the prolonged river. The freshet water might escape over extended waste-weirs immediately into the head of the bay. In that case a rise at Mobile of 1.8 feet, provided the river bed remains constant, will give the requisite velocity for the outflow. It cannot be expected, however, that the bed of the river will maintain its present level for a distance of 24 miles. It must gradually rise, and with it the surface, and therefore the banks. Now, as the city wharves are only 3½ feet above ordinary high-water and are occasionally overflowed, it seems conclusive that without building levees above and below Mobile and along its whole front the transfer of the river mouth to the lower bay will inundate a part of the city frequently. The river extension proposed is, therfore, regarded by the Board as impracticable.

The Board now present two projects which are to a certain extent modifications of Captain Damrell's plan.

The first is to turn the waters of the Mobile branch down the west shore of the bay by extending its east bank to Alabama Port or as far as may be found necessary, to cover a channel formed by dredging. The second is to bring this channel into the Mobile branch by a cut across Choctaw Point to be closed by gates; or, avoiding the cost of this cut, to connect with the city by piers at Garrow's Bend, local interests determining the choice between these termini. Well covered as this channel will be against waves by its artificial bank, a width of 100 feet is deemed sufficient for the accommodation of the large vessels alone compelled to use it. This construction will in no wise interfere with navigation in the river or bay during its progress. The channel will have no current except the bay current, and will not, therefore, silt up; nor

will the bank require any protection on the channel side. It can be formed principally from the material excavated to create the channel, consolidated by small trees, saplings, and brush, which grow abundantly along the shore. It seems probable that some stone will be required to assist in the solidification of this artificial bank. As the bay along the line of its location is quite shoal, varying from 3 to 9 feet, its construction need not be expensive, unless extended beyond Alabama Port farther than is necessary to resist wave action. Any estimate, however, must be at best but approximate, as so much will depend upon the cost of securing its bank against abrasion, and of extending it into the deep water beyond Alabama Port, should such extension be found necessary.

Of these two projects thus summarily presented, the second, which terminates the channel at Garrow's Bend or extends it to the river by a cut through Choctaw Point, is, in the opinion of the Board, much preferable to the first.

Much expense will be saved by terminating the channel at Garrow's Bend; but there may be sufficient reasons for continuing it into Mobile River so that vessels of a large class may ascend to the present city wharves. To prevent silt depositing within the cut, gates seem necessary; otherwise an open entrance would be preferred.

This project is exhibited in a general way on accompanying sketch (A). Exactness of location and precise methods of construction both of the east bank of the channel and the gate structure are left to be determined hereafter, should the project be adopted.

There is a question connected with the maintenance of a deep channel excavation in Mobile Bay which can only be solved experimentally.

It seems that after passing through a crust of sand and stiff clay, at a depth of from 14 to 16 feet below the water surface, boring has revealed a layer of soft mud, which continues to a depth of 30 feet, as far as the auger penetrated. The boring rod, $4\frac{1}{2}$ inches in diameter, went down of its own weight (247 pounds) $8\frac{1}{2}$ feet; thence, with weight increased to 517 pounds, it sank $5\frac{8}{10}$, reaching a depth of about 30 feet below water-level. Hitherto the dredging has stopped in stiff clay at 13 feet depth. If it be carried 9 feet deeper through this soft clay or mud will the channel remain open, or will side pressure cause its gradual filling by lateral motion of this yielding material? As there will be no rapidly-flowing current to keep open this channel, once dredged in the bay, should it tend to fill by mud flowing in from either side, dredging a second time will be needed; in other words, the method will be a failure. It seems proper, therefore, as a preliminary step, that the experiment be made of dredging the present channel—say, on Dog River Bar—for a length of 100 yards and width of 100 feet, and to a depth of 22 feet below the surface of the water in the bay, and that the excavated portion be carefully sounded from time to time to ascertain its condition. Should the channel fill with mud, it would be a waste of money to attempt to attain a permanent water-way 22 feet deep. On the contrary, should there be no evidence of filling by side pressure, that objection to a dredged channel would come to naught.

The foregoing question being decided in the affirmative by trial, this Board is of the opinion that if the present and prospective commerce of Mobile demands a channel of 22 feet depth from the lower bay to the city, it should be obtained by dredging the west shore of the bay, to connect with Mobile either at Garrow's Bend or by a cut through Choctaw Point into the river. But if 17 feet depth will satisfy the shipping

interests of this port, the Board recommends that it be attained by dredging the present channel.

APPROXIMATE ESTIMATE

for securing a channel 22 feet deep from lower anchorage of Mobile Bay to Garrow's Bend, on the supposition that the east bank for the protection of the channel is built in water of an average depth of 9 feet, and extended no farther south than Alabama Port. Side slopes of prism excavated are assumed at 1 upon 2. The average prism, therefore, to be dredged will measure:

	Feet.
Width at top	152
Width at bottom	100
Depth	13

	Cubic yards.
Excavation of channel from Choctaw Point to Alabama Port, 113,322 feet in length	6,874,868
Excavation from Alabama Port to deep water, 23,448 feet in length	604,507
Total excavation	7,479,375

3,437,434 cubic yards to be dumped alongside channel to form dike, at 15 cents	$515,615 10
3,437,434 cubic yards placed on upper portion of dike, at 20 cents	687,486 80
604,507 cubic yards beyond Alabama Port, at 20 cents	120,901 40
Cost of excavation of channel	1,324,003 30

To consolidate the dike formed of mud and sand dredged from the channel, some nucleus, as brush made into rafts or mattresses and covered over above water with stone ballast, or two rows of piles filled in with brush closely packed and covered over above the water surface with ballast, will be needed. If stone ballast can be procured as cheaply in Mobile Bay as it can at the North, it is estimated that this nucleus can be built for about $10 per running foot.

113,322 running feet of central structure of dike, at $10	$1,133,220 00
Add cost of excavation	1,324,003 30
Total cost to Garrow's Bend	2,457,223 30
Extension to Mobile River	150,000 00

Should it be necessary to extend the dike beyond Alabama Port as a protection against cross-currents, the structure in deep water will be much more costly. We may, therefore, set down the probable cost of creating a channel along the western shore of Mobile Bay to the city, from the lower anchorage, to be 22 feet deep, 100 feet wide at bottom, and protected by a dike extended to Alabama Port, or as far as shall be found necessary, as between $2,500,000 and $3,000,000.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brevet Major-General.
JOHN NEWTON,
Colonel of Engineers, Brevet Major-General.
HENRY L. ABBOT,
Major of Engineers, Brevet Brigadier-General.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

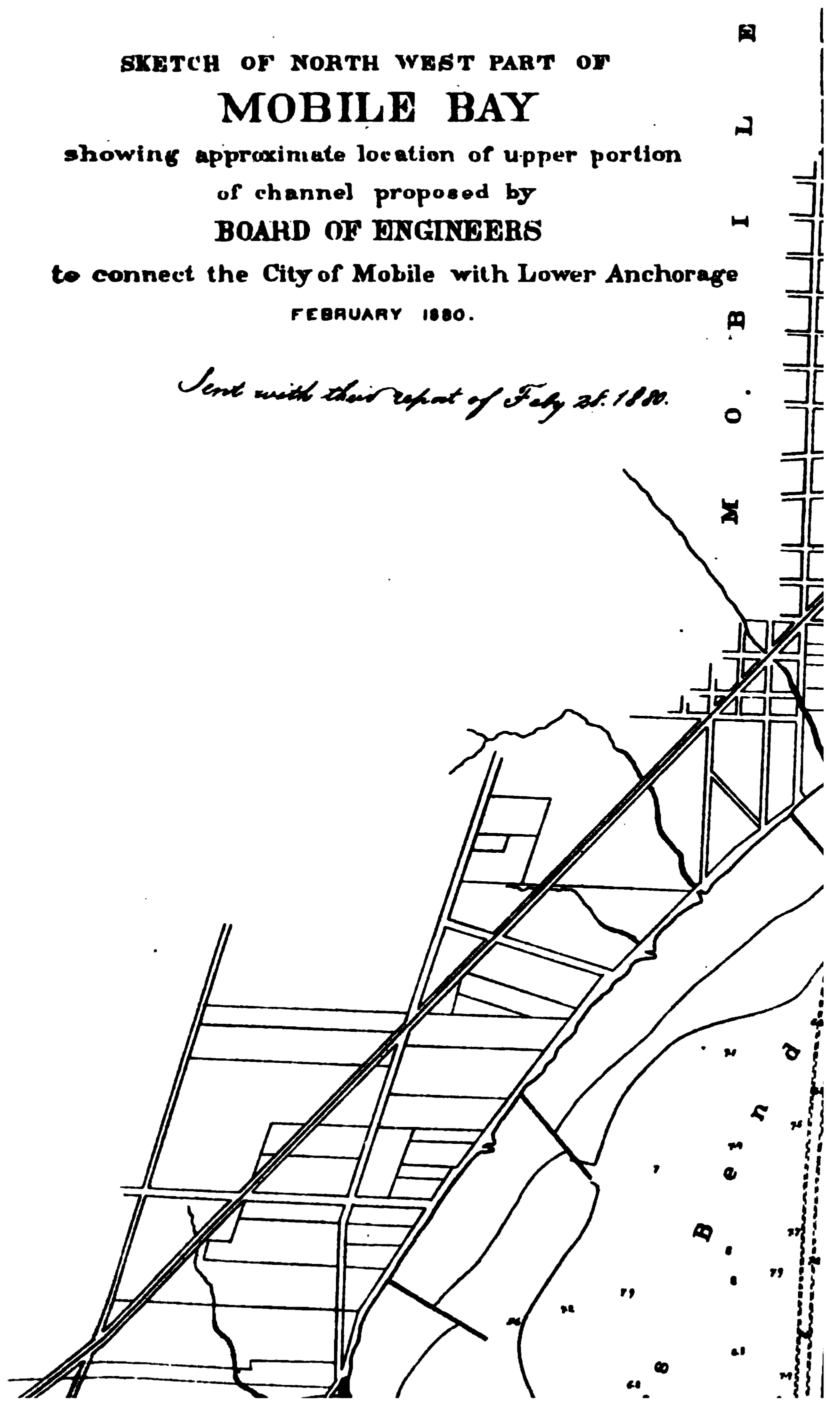
SKETCH OF NORTH WEST PART OF

MOBILE BAY

showing approximate location of upper portion
of channel proposed by
BOARD OF ENGINEERS
to connect the City of Mobile with Lower Anchorage

FEBRUARY 1880.

Sent with their report of Feby 25. 1880.



K 2.

IMPROVEMENT OF PENSACOLA HARBOR, FLORIDA.

The improvement of this harbor was commenced November, 1878, by the removal of four wrecks at or near the entrance of the harbor, under an appropriation of $20,000, made by act of Congress, approved June 18, 1878.

Under a contract made with Mr. G. W. Le Gallais, the wrecks of the bark Ada, the ship Miles, the steamer Convoy, and the pilot-boat Nettle were to be removed by May 1, 1879, but on account of stormy weather the contractor was unable to complete the work at the specified time, and an extension of time to complete his contract was granted him until July 1, 1879.

Under the same appropriation a survey of the entrance to Pensacola Harbor, for the purpose of ascertaining the cause of the shoaling of the main ship channel, south of the Middle Ground, was commenced and completed during the last fiscal year, and for a full report of same, with my recommendations as to further improvements, I would respectfully refer to Annual Report of the Chief of Engineers for 1879, Appendix J 2, p. 801.

As above stated, the contract for the removal of the four wrecks had been extended to July 1, 1879, but at that time the work was far from being completed. The wrecks of the pilot-boat Nettle and the bark Ada were reported by the contractor as completely removed; those of the ship Miles and the steamer Convoy only partially. As this delay in the completion of the contract was entirely caused by the inclemency of the weather, a further extension of time until August 15, 1879, was granted.

On August 9, 1879, the contractor reported all four of the wrecks removed, according to the terms of the contract. Upon a thorough inspection of the grounds where the wrecks had been located, by an experienced diver, made between the 11th and 19th of August, it was found that the wrecks of the pilot-boat Nettle and the steamer Convoy had been completely removed, while portions of those of the ship Miles and bark Ada were still found buried in the sand. A further extension of time being granted the contractor, he continued work until December 15, 1879, and upon a second examination of the grounds where the wrecks of the ship Miles and bark Ada were located, it was found that their complete removal had been accomplished, and the contract completed.

No further work was done during the balance of this year.

Since the completion of the survey in 1879, no observations have been made in regard to any changes which may have taken place during the year. The abrasion of the western shore still continues, but no material increase in the shoaling of the main ship channel has been reported.

By act of Congress approved June 14, 1880, an appropriation of $40,000 was made for the improvement of this harbor, and the following project for the expenditure of this, and balance available from former appropriation has been submitted, viz: To dredge a channel through the inner bar that has recently formed, and to construct as much of the training-wall, according to project submitted with annexed report for 1879, as the appropriation will allow.

The work to be done by contract, provided reasonable bids are received, otherwise the work to be done by hired labor. An appropriation of

$100,000 is asked for fiscal year ending June 30, 1882, to be applied to the construction of the retaining wall on the west side of the channel in front of Fort McRee.

The total cost, as estimated, for the work proposed is $177,250, and the amount required to complete the work, exclusive of former appropriations, is $124,152, but if the materials of the ruins of Fort McRee can be used as part of the ballast, it is estimated that the amount asked for will complete the work to the extent of the present project.

The removal of the wrecks, accomplished during the year, not only lessens the dangers of navigation, but it may reasonably be supposed that one of the causes which tended to the formation of the inner bar is thereby removed.

The improvement contemplated—the deepening of the main ship-channel to its former depth of 24 feet—will not only exert a beneficial influence upon the commerce of Pensacola, in so far as it will permit this place, if not to immediately increase, at least to retain its already large trade, but will also enable our vessels of war, of the above draught, to reach Pensacola navy-yard without detention.

The work is located in the collection district of Pensacola, Fla., with Pensacola as the port of entry, and is situated near Forts Pickens and McRee and Pensacola light-house.

The following statistical statement of the commerce of Pensacola for the fiscal year ending June 30, 1880, has been furnished me by the collector:

Duties on imports and sale of unclaimed goods	$10,864 86
Tonnage dues	50,882 35
Hospital tax	1,872 38
Official fees	3,441 20
Steamboat inspections	275 00
Total	67,335 79
Amount of exports to foreign countries	1,930,639
Amount of shipments coastwise	335,346
Total	2,265,985

Foreign vessels entered: 334 vessels, 233,043 tons, 4,867 men. Foreign vessels cleared: 346 vessels, 243,249 tons, 4,961 men. American vessels entered from foreign countries: 64 vessels, 23,244 tons, 506 men. American vessels cleared to foreign countries: 31 vessels, 11,001 tons, 265 men. Vessels entered coastwise: 192 vessels, 63,947 tons, 2,078 men. Vessels cleared coastwise: 211 vessels, 55,652 tons, 2,092 men. Total number of vessels entered: 590 vessels, 320,234 tons, 7,451 men. Total number of vessels cleared: 588 vessels, 309,902 tons, 7,288 men.

Money statement.

July 1, 1879, amount available	$16,779 48	
Amount appropriated by act approved June 14, 1880	40,000 00	
		$56,779 48
July 1, 1880, amount expended during fiscal year		3,681 41
July 1, 1880, amount available		53,098 07
Amount (estimated) required for completion of proposed project		124,470 52
Amount that can be profitably expended in fiscal year ending June 30, 1882		100,000 00

K 3.

IMPROVEMENT OF HARBOR AT CEDAR KEYS, FLORIDA.

Provision was made for the survey of this harbor by act of Congress approved June 10, 1872.

The survey was made from August to December, 1872, and the report upon it was made in 1873, and is contained in the annual Report of the Chief of Engineers of that year.

The project recommended at that time was to dredge a channel 100 feet wide and 10 feet deep across the bend in the main channel passing to the westward of Harbor Key. It was afterward modified so as to obtain in the same manner a channel 12 feet deep, or as deep as the underlying limestone would permit from the Gulf of Mexico to Cedar Keys.

During the progress of the work in 1877 another change was made, which it was thought would reduce the cost materially and accomplish the same result. This change was to make a cut across the middle ground between Way Key and Depot Key, instead of the one first proposed across the bend in the main channel passing to the westward of Harbor Key.

The present plan is therefore to dredge a channel 200 feet wide and as deep as the underlying limestone will permit, not exceeding 12 feet, through the outer bar and the middle ground between Way Key and Depot Key, and to make slight improvements by dredging portions of the channel.

The original estimated cost of this work was		$133,500 00
The amounts appropriated are as follows:		
Act approved June 10, 1872	$7,500 00	
Act approved March 3, 1875	15,000 00	
Act approved August 14, 1876	10,000 00	
Act approved June 18, 1878	20,000 00	
Act approved March 3, 1879	15,000 00	
Act approved June 14, 1880	15,000 00	
		82,500 00
Total		51,000 00

The first appropriation was expended in dredging by contract on the outer bar. The second at the same place and in the same manner. The third was applied to dredging a cut through the middle ground, and the balance on the outer bar and making slight improvements in the main channel between Sea Horse and Harbor Keys. The fifth has been and is being used in the removal of the wreck of the steamer Lewisburg and widening the dredged channel through the outer bar.

The results obtained up to the close of the fiscal year ending June 30, 1879, were a cut 200 feet wide and 11½ feet deep (down to the limestone) through the middle ground, another 100 feet wide and 12 feet deep through the outer bar.

During the fiscal year ending June 30, 1880, the wreck of the steamer Lewisburg was removed and 14,273 cubic yards were excavated by contract on the outer bar in the process of widening the cut.

It is proposed to use the appropriation made by act of Congress approved June 14, 1880, and the balance of the appropriation made by act approved March 3, 1879, in widening the cut through the outer bar and completing the project.

The improvement already effected seems to have been of considerable value to Cedar Keys.

The town has increased in population and in the number and character of its buildings. Local trade is reported to have increased fully 60 per cent. Tonnage, imports, exports, and revenue have all increased considerably during the past year.

This work is in the collection district of Cedar Keys, and Cedar Keys is the port of entry.

The following are the commercial statistics as furnished by the collector of customs:

Value of foreign imports	$7,280 00
Value of exports to foreign ports	5,061 00
Amount of revenue collected	8,500 00
Total number of vessels	187
Tonnage of same	103,938
Total number of vessels cleared	143
Tonnage of same	75,178
Value of pine and cedar lumber shipped	$352,000 00
Value of other commerce	105,000 00

Money statement.

July 1, 1879, amount available	$21,107 71	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$36,107 71
July 1, 1880, amount expended during fiscal year	9,424 38	
July 1, 1880, outstanding liabilities	33 90	
		9,458 28
July 1, 1880, amount available		26,649 43

Abstract of bids received and opened November 5, 1879, for dredging in the harbor of Cedar Keys, Florida.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	James E. Slaughter	$0 69.9	On or before the 1st day of February, 1880.	On or before the 1st of June, 1880.
2	S. N. Kimball	95		

Abstract of bids received and opened November 5, 1879, for removal of wreck of steamer Lewisburg, in the harbor of Cedar Keys, Florida.

No.	Name of bidder.	Price of entire removal of work.
1	James E. Slaughter	$1,999
2	S. N. Kimball	3,900

K 4.

IMPROVEMENT OF CHATTAHOOCHEE RIVER, ALABAMA AND GEORGIA.

The survey for this improvement, directed by acts of Congress approved March 31, 1871, and June 10, 1872, was made from Columbus to Chattahoochee. The preliminary report was submitted July 31, 1872.

The final report was submitted in the annual report from this office for fiscal year ending June 30, 1873, and forms a part of the annual report of the Chief of Engineers for that year.

The project adopted for the improvement was to obtain a good navigable channel, 100 feet wide and 4 feet deep at low-water, throughout the whole distance from Columbus to Chattahooche, by the removal of snags, wrecks, and loose rocks, and the improvement of a number of bars by blasting, dredging, and the construction of dams and wing-dams.

The estimated cost of the improvement was $145,247.66.

The appropriations since made are as follows:

By act of Congress approved June 23, 1874	$25,000 00
By act of Congress approved March 3, 1875	25,000 00
By act of Congress approved August 14, 1876	20,000 00
For the Chattahoochee and Flint together	70,000 00
For the Chattahooche by itself:	
By act of Congress approved June 18, 1878	$18,000 00
By act of Congress approved March 3, 1879	15,000 00
By act of Congress approved June 14, 1880	20,000 00
Total	53,000 00

No separate account was kept of the expenditures on the Chattahoochee and Flint rivers when the appropriation was made for the two together; but I am satisfied the estimated cost of this work will be exceeded by $35,000 or $45,000, on account of the necessary repair required to works constructed each subsequent year, and the annual removal of snags which lodge in the river after every freshet—the cost of both these items being about $5,000 per year which has been expended each year since the commencement of the work, and should be charged to the preservation of the improvement rather than to the improvement itself.

The work accomplished on the improvement to June 30, 1879, was as follows:

The snags and overhanging trees obstructing or endangering navigation of the river at the commencement of this work were removed, as well as the annual accumulations since. Upatoi and Woolfolk Bars were improved by a system of timber and brush wing-dams so as to give the width and depth required by the project.

A shore protection was constructed at Shell Creek Bar, Little Uchee, reef below Little Uchee, Slick Bluff, roils below Slick Bluff, and the middle rocks in Uchee and Hardridge's Shoals were all opened by blasting to the full depth but not to the full width required.

During the last fiscal year a barge, 50 by 20 feet, with quarters for laborers and hoisting-derrick; a magazine-boat, 25 by 12 feet; a dumping-scow, 30 by 15 feet; and a scow for pile-driving, 50 by 24 feet, were built. The remainder of the work is given in the following table:

Tabular statement of progress made during the fiscal year ending June 30, 1880.

Names of places.	Number miles below Columbus, Ga.	Original depth, in feet.	Present depth, in feet.	Original width, in feet.	Present width, in feet.	Linear feet drilled.	Number blasts made.	Average charge, in pounds.	Cubic yards rock removed.	Number snags removed.	Number overhanging trees.	Linear feet jetty built.	Number boats built.	Remarks.
[illegible]nie's Island	6													Barge sunk to obstruct false channel.
Abercrombie's Bar	8	1	3½	350	150							711		Brush wing-dams.
Woolfolk's Bar	10	1½	4	500	150							145		Do.
Upatoi Bar	11	2	4	300	150							855		Do.
Uchee Shoals	19	1½	4	35	65	616	120	2½	580					Rocks blasted.
Culpepper Island	32	2	4	400	150							982		Brush wing-dams.
Various places										43	8		4	
						616	120	2½	580	43	8	2,693	4	

The whole improvement effected since the commencement of the work is shown by the following table, except the removal of snags and overhanging trees, which has been carried the whole length of the river to be improved:

Names of places.	Below.	Miles.	Above.	Miles.	Original depth, in feet.	Present depth, in feet.	Original width, in feet.	Present width, in feet.	Remarks.
Abercrombie's Bar	Columbus, Ga.	8	Enfaula, Ala.	77	1	3½	350	150	Contracted with wing-dams.
Woolfolk's Bar		10		75	1½	4	500	150	Do.
Upatoi Bar		11		74	2	4	300	150	Do.
Shell Creek Bar		24		64	3	3	350	350	Shore protection.
Little Uchee Shoals		17		68	2	4	50	60	Reef blasted; too narrow.
Reef below Little Uchee.	Enfaula, Ala.	17½	Fort Gaines, Ga.	67½	1½	4	50	60	Do.
Slick Bluff Reef		18		67	0	4	39	55	Part of dry reef blasted off.
Middle Rocks		18½		66½	1½	4	30	80	
Big Uchee Shoals		19		66	1½	4	35	65	
Culpepper Island Bar.		32		53	2	4	400	150	
Hardridge's Shoal		27		6	2	4	35	80	

It is proposed to apply the funds available for expenditure, during fiscal year ending June 30, 1881, as follows:

To removing the wreck of the steamer Big Foot, at Roanoke Island.

Repairing old jetty at Woolfolk's Bar.

To improving the river channel at Jennie's Island, Mound, Francis, and Preston Bars, so as to give a channel of 4 feet depth at low-water, by scour, produced by contracting the low-waterway by means of brush wing-dams.

To improving the channel at the rock shoals known as Belton's and Cody's Rocks, Snake, Averitt's, Oak Log, Baltimore, Roanoke, Cowackee, and Morgan's Shoals, by widening and deepening, by blasting.

To snagging the whole length of the river.

It is proposed to apply the appropriation asked for fiscal year ending June 30, 1882, in accordance with the above project.

The total value of merchandise transported during the fiscal year amounts, in round numbers, to $4,398,000 against $3,760,000 last year, showing a gain of $637,000 or about 20 per cent. The river freights aggregate $196,800 against $156,558 last year, a gain of $40,242 or nearly 40 per cent.

It is expected that the business will continue to increase from year to year as the navigation is improved.

This work is situated in the collection districts of Savannah, Brunswick, and Saint Mary's, Ga.

The nearest port of entry is Savannah, Ga.

The amount of revenue collected for fiscal year ending June 30, 1880, is $49,417.01

This improvement will not be permanent in its character, when completed, and it is estimated it will require an annual expenditure of about $3,000 to preserve it, in removing snags and overhanging trees, repairs to dams and wing-dams, and shore protection to prevent caving banks.

Money statement.

July 1, 1879, amount available	$27,454 82	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$47,454 82
July 1, 1880, amount expended during fiscal year		10,250 16
July 1, 1880, amount available		37,204 66
Amount (estimated) required for completion of existing project		85,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		80,000 00

K 5.

IMPROVEMENT OF FLINT RIVER, GEORGIA.

The survey for this improvement was directed by act of Congress approved June 10, 1872, and was made between November, 1872, and May, 1873. Report was submitted upon it in the annual report from this office for the fiscal year ending June 30, 1873, and is contained in the Annual Report of the Chief of Engineers for that year.

The project adopted for the work was to obtain a channel 100 feet wide and 3 feet deep by removing snags and overhanging trees, loose rocks on various shoals, and blasting channels through several others.

The estimated cost of the improvement from Chattahoochee to Albany, Ga., was $184,862.

The amounts appropriated since are as follows:

Chattahoochee and Flint:	
By act of Congress approved June 23, 1874	$25,000 00
By act of Congress approved March 3, 1875	25,000 00
By act of Congress approved August 14, 1876	20,000 00
By act of Congress approved June 18, 1878	10,000 00
By act of Congress approved March 3, 1879	7,000 00
By act of Congress approved June 14, 1880	20,000 00
Total for Chattahoochee and Flint together	70,000 00
Total for Flint River by itself	37,000 00

The last act, however, prescribed that $10,000 of the amount appropriated should be expended between Albany and Montezuma, a portion of the river not included in the original estimate, but which was examined under direction of the act of Congress approved June 18, 1878. This examination was made from December, 1878, to January, 1879. Report was submitted February 6, 1879, and is contained in the annual report of the Chief of Engineers for the fiscal year ending June 30, 1879.

The project adopted for this portion of the river was to remove snags and overhanging trees, so as to give a navigable channel throughout (an estimated distance of 77 miles) for light draught steamers when the water was a little above the low-water stage.

The estimated cost of the work was $15,100. The estimated cost of the work as now carried on would therefore be $199,962.

The work accomplished up to the 30th of June, 1879, was as follows:

The river was improved thoroughly, so as to give a good navigable channel of the projected width and depth from the mouth up as far as Bainbridge, Ga., except at Rob's Rocks, by the removal of snags, overhanging trees, opening a channel on the west side of Lambert's Island, and the removal of the following rock shoals: Rob's (not quite completed), Broad Axe, Bryant's, Versailles, and those at the railroad and Bainbridge City wharves. Above Bainbridge, Fodderstack, Cross Chute,

and Red Bluff Shoals were improved, so as to give the required channel, and Arnett's Bridge, at Bainbridge, was removed. A new hull was built for the blasting barge.

During the fiscal year ending June 30, 1880, the work performed on this river is as follows:

The channel of the river, to the projected depth and width, was completed by the removal of rock, sometimes loose and at other times extending all the way across the river, between Red Bluff and Bainbridge, thus completing the improvement from the mouth to Red Bluff, 10 miles above Bainbridge. Work was commenced on Winding Shoals, 22 miles above Bainbridge. A working barge, 60 by 20 feet, with quarters and hoisting derrick, and dumping scow, 35 by 18 feet, were also built.

The following table shows in detail the progress made during the year:

Names of places.	Number of miles above Bainbridge.	Original width, in feet.	Present width, in feet.	Original depth, in feet.	Present depth, in feet.	Linear feet drilled.	Number of pounds of powder.	Number of blasts.	Rock removed, cubic yards.	Snags removed.	Barges built.	Barges repaired.
Below Cotton Factory	2	55	100	1	4	36	50	10	42	16	....	....
Three Rock Reach	3	30	100	1	4	76	95	19	67	37	....	....
Middle Reach	6	40	100	0½	4	72	90	18	185	3	....	....
Below Red Bluff	8	20	100	1½	4	20	25	5	149	15	....	....
Red Bluff	10	40	100	1½	4	3	5	1	263	20	....	....
Winding Shoals*	22	40	100	1	4	21	19	9	576	12	....	....
	......	......	......	......	....	......	......	....	......	......	2	1
Total		......	......	......	....	228	284	62	1,282	103	2	1

* When finished.

Since the commencement over 50 miles of river have been cleared, so as to give a good navigable channel the entire year.

The following table gives location of principal shoals improved with depth and width of channel before and after improvement:

Names of places.	Miles below Bainbridge.	Miles above Bainbridge.	Original width, in feet.	Present width, in feet.	Original depth, in feet.	Present depth, in feet.	Remarks.
Lambert's Island	12	......	......	100	1	3	New channel opened on west side of island.
Rob's Rock	10	......	60	100	0	2	Isolated dry bowlder, not finished.
Broad Axe Rock	9½	......	50	100	½	4	Bowlder in mid-channel.
Bryant's Rock	4½	......	70	100	½	4	Bowlder on point.
Versailles Rock	2	......	50	100	0	4	Bowlder in mid-channel.
Bainbridge	0	......	100	100	1	4	Several rocks near wharf.
Fodderstack Shoals	......	12	80	100	0	4	Dry ledge removed to widen channel.
Cross Chute	......	11	75	100	0	4	Do.
Below Cross Chute	......	4	30	100	½	4	Loose rocks taken out.
Three-Rock Reach	......	3	40	100	½	4	Do.
Winding Shoals	......	22	40	100	1	4	Work progressing.

It is proposed during the next fiscal year to continue this work at Winding Shoals to completion and then to drop down, removing Craw-

ford's Point and such other obstructions as may be encountered, until Fodderstack Shoals are reached, which will join up to the work below, and complete the improvements from the mouth to Winding Shoals, 22 miles above Bainbridge, Georgia. It is then proposed to tow the boats to Hell-Gate, 1 mile above Winding Shoals, and work on up stream as far as the funds will permit.

The proposed application of the appropriation asked for the fiscal year ending June 30, 1882, is to continue the work on to Newton and as far above towards its completion as the appropriation will permit.

There is at present no commerce above Bainbridge, Georgia, and the improvements will be practically dormant until Newton is reached. The citizens declare that they will have a line of boats on as soon as the river is in condition to receive them.

From the best information that could be obtained it is believed the river business below Bainbridge is about 10 per cent. greater than last year.

This improvement may be considered as reasonably permanent, and it is estimated that an annual appropriation of $2,000 for five years after the completion of the work will be sufficient to preserve the improved channel as far up as Albany. It is impossible to estimate at present for that portion below Albany and Montezuma.

This work is situated in the collection district of Brunswick and Saint Mary's, Georgia; and Apalachicola, Florida, is the nearest port of entry.

Money statement.

July 1, 1879, amount available	$10,870 49	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$30,870 49
July 1, 1880, amount expended during fiscal year		8,002 97
July 1, 1880, amount available		22,867 52
Amount (estimated) required for completion of existing project		167,829 52
Amount that can be profitably expended in fiscal year ending June 30, 1882		50,000 00

K 6.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

The survey for this improvement was directed by act of Congress approved June 10, 1872, and was made between November, 1872, and February, 1873. The report on the same was made in the annual report from this office for the fiscal year ending June 30, 1873, and forms a part of the Annual Report of the Chief of Engineers for that year.

The project adopted for the improvement was to obtain a good navigable channel of 6 feet depth of water from its mouth up to the river Styx; through that river to Moccasin Slough, through the slough to the Apalachicola River again, and up it, to its head, by the removal of snags and straightening and widening the channel of Moccasin Slough.

The estimated cost of the work was		$80,333 00
The appropriations already made are as follows:		
By act of Congress approved June 23, 1874	$10,000 00	
By act of Congress approved March 3, 1875	10,000 00	
By act of Congress approved June 18, 1878	8,000 00	
By act of Congress approved March 3, 1879	5,000 00	
By act of Congress approved June 14, 1880	2,000 00	
		35,000 00
		45,333 00

With these appropriations up to the close of the fiscal year ending June 30, 1879, snags and overhanging trees were removed from Apalachicola to the head of the river, 136 miles, following the line mentioned in the project. In addition to the obstructions of this character in the river at the beginning of the work, large accumulations which formed each year since were removed.

Improvements were also made at the upper and lower end of Moccasin Slough. Those at the upper end, although improving the channel, did not accomplish all that was desired.

Chipola Cut-off, although not included in the original project, was improved, by authority of the Chief of Engineers, from its upper end to White's Bluff, a distance of 9 miles, giving access by steamer to the orange-groves along Dead Lake.

During the past fiscal year a canal was cut across the peninsula between Apalachicola River and the upper end of Moccasin Slough, 70 feet wide and 5 feet deep, to avoid the abrupt turn at the junction; 3,611 cubic yards of sticky blue clay with a great many cypress logs and stumps were removed in the work, which was three times stopped by freshets. A raft of several hundred logs was removed at Styx Island, and another near the mouth of Styx River.

It is proposed to apply the funds available for expenditure during fiscal year ending June 30, 1881, in completing the canal at Moccasin Slough, and in removing either Styx Island or the point opposite, and keeping the channel clear of snags.

The proposed application of funds asked for the fiscal year ending June 30, 1882, will be to keep the improvements already completed in repair, to keep the channel free from obstructions, and, if found necessary, to improve Bluntstown Bar by a system of wing-dams.

The present commerce on this river is insignificant when compared with its former proportions. This diminution is due to railroad competition and the shallow outlet at Apalachicola. With the river bar deepened to 11 feet a fresh impetus would spring up, and the river commerce would probably be increased to a great extent.

This work is situated in the collection district of Apalachicola.

Apalachicola is the nearest port of entry. The amount of revenue collected during fiscal year ending June 30, 1880, $292.50.

Money statement.

July 1, 1879, amount available	$9,589 36	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$11,589 36
July 1, 1880, amount expended during fiscal year		5,683 97
July 1, 1880, amount available		5,905 39
Amount (estimated) required for completion of existing project		45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		5,000 00

K 7.

IMPROVEMENT OF APALACHICOLA BAY, FLORIDA.

A survey for this improvement was provided for by act of Congress approved July 11, 1870. Report of the survey is contained in the Annual Report of the Chief of Engineers for 1872, pp. 612 to 623. A re-

-xamination was made in December, 1878, report of which is contained in Annual Report of the Chief of Engineers for 1879, pp. 823 to 824.

The plan adopted consists in dredging a channel through the bar at the mouth of the Apalachicola River, 100 feet wide and 11 feet deep at mean low-water, following the natural line of deepest water.

The first appropriation, $10,000, was made by act of Congress approved June 14, 1880.

With the amount thus made available it is proposed to commence dredging, according to the plan, by contract. It is proposed to apply the appropriation asked for in continuing the work.

The work would not probably be permanent, but would require more or less dredging every three or four years to keep the channel open to its full length and depth.

The commerce to be benefited is given in the following statement from the custom-house records:

Amount of revenue collected at the port of Apalachicola, Fla., during the fiscal year ending June 30, 1880, $292.50. Marine-hospital dues collected, $392.81.

	Vessels.	Tons.
Coastwise arrivals	24	6,265
American, from foreign countries	6	2,270
Foreign, from foreign countries	1	465
	31	9,000
Coastwise clearances	33	7,774
American vessels from foreign countries	4	913
	37	8,687

Vessels owned in this district, 27; 1,459 tons.

An appropriation of $90,000 is asked for fiscal year ending June 30, 1882.

This work is in the collection district of Apalachicola, Fla., and Apalachicola is the port of entry.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	90,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	90,000 00

K 8.

IMPROVING TAMPA BAY, FRORIDA—DEEPENING THE BAR AND CHANNEL FROM THE BAR TO THE TOWN OF TAMPA.

The examination for this improvement was provided for by act of Congress approved June 18, 1878. It was made from Egmont Key, at the entrance to Tampa Bay, to the wharves at Tampa in the Hillsborough River. The report upon it is contained in the Annual Report of the Chief of Engineers for 1879, pp. 870 to 873.

The project adopted is to deepen the present or old channel by dredging to 9 feet, with a width of 200 feet in the river and 150 feet in the bay, from Ballast Point to Tampa.

The first appropriation, $10,000, was made by act of Congress approved June 14, 1880. It is proposed to expend this amount in dredging, according to the above plan, by contract.

It is proposed to expend the amount asked for in continuing work according to the plan. The improvement would not probably be permanent. It is not possible to estimate the cost of keeping the improvement when once effected, but probably a small amount compared with original cost of work will be required.

The value of the commerce to be benefited is given by merchants of Tampa at $500,000. Tonnage of vessels entering the port, 2,500. Number of cattle shipped from Tampa to Cuba, 15,000.

This work is in the collection district of Cedar Keys, Fla., and Cedar Keys, Fla., is the nearest port of entry.

An appropriation of $87,000 is asked for fiscal year ending June 30, 1882.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	87,002 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	87,000 00

K 9.

IMPROVEMENT OF SUWANEE RIVER, FLORIDA.

The examination of this work was provided for by act of Congress approved June 18, 1878, and was made from its mouth to the bridge of the Jacksonville, Pensacola and Mobile Railroad, just below the mouth of the Withlacoochee River, near Ellaville, Florida. The report was made August 26, 1879, and is contained in the Annual Report of the Chief of Engineers for 1879, pp. 857 to 863.

The plan adopted was to dredge a channel through the bars at East and West Passes, 5 feet deep and of sufficient width for the vessels employed in the commerce of that locality; to remove the snags, and improve the shoals in the river, so as to give a depth of 5 feet as high up as Roland's Bluff, and from there to Ellaville of 4 feet.

The first appropriation for the work, $5,000, was made by act of Congress approved June 14, 1880, which amount it is proposed to expend in dredging through the bar at East Pass, by contract, according to the adopted plan, as far as the appropriation will admit.

It is proposed to expend the amount asked for in continuing the work according to the plan. It is not thought the improvement will be permanent, but that a small amount of dredging will be required from time to time. The commerce to be benefited is principally in pine, cypress, and cedar timber, 2,000,000 feet of which were shipped last year. Cotton, sirup, and other farm products in limited quantity are also annually shipped, chiefly to Cedar Keys, from points on the Suwanee River.

This work is situated in the collection district of Saint Mark's, Fla., and Cedar Keys is the port of entry.

An appropriation of $50,000 is asked for fiscal year ending June 30, 1882.

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00
Amount (estimated) required for completion of existing project	50,158 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	50,000 00

K 10.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, ALABAMA AND FLORIDA.

The examination of this river was made under authority of an act of Congress approved March 3, 1871, from its mouth to Geneva, in the winter of 1871-'72. The report was submitted April 6, 1872, and is contained in the annual report of the Chief of Engineers for that year.

The project adopted for this improvement was to remove such obstructions as rendered the navigation of the river difficult and dangerous for the amount of trade on the river at that time.

The estimated cost of carrying out the project was		$34,332 00
The amounts appropriated have been as follows:		
By act of Congress approved June 23, 1874	$5,000 00	
By act of Congress approved March 3, 1875	5,000 00	
By act of Congress approved August 14, 1876	5,000 00	
By act of Congress approved March 3, 1879	5,000 00	
By act of Congress approved June 14, 1880	7,000 00	
		27,000 00
		7,332 00

The work accomplished under these appropriations up to the end of the fiscal year ending June 30, 1879, was as follows:

The river was cleared of snags and overhanging trees from its mouth about 100 miles up. Several sand and gravel bars were removed, and a channel 30 feet wide, 3 feet deep at mean low-water, and 150 feet long was cut through a rock shoal about 1 mile above Cerro Gordo, or Hewitt's Bluff.

During the fiscal year ending June 30, 1880, about 20 miles more of the river were cleared of snags and overhanging trees. Three months' time was consumed in removing snags and other obstructions to navigation which had accumulated in that portion of the river previously worked, as a result of one of the highest freshets known on this river, which occurred in October, 1879.

A cut-off was opened by the removal of snags, stumps, and overhanging trees, giving a channel 60 feet wide and 7 feet deep, to enable boats to avoid the obstructions caused by the wreck of the steamer eighth of January, the removal of which was prevented by too high a stage of water.

Buzzard Bar Cut off, 15 miles below Geneva, was also cleared out thoroughly in the same manner, giving a good navigable channel, with from 3 feet to 6 feet where there was formerly from 14 inches to 2 feet, and which is still deepening.

The greater portion of the wreck of the steamer Boston, including upper deck, side next to the channel, shaft, cranks, flanges, cylinders, engine-beds, and other parts of the machinery, was removed and placed upon the bank opposite. The part not removed is far enough below the lowest stage of water not to interfere with navigation.

Five hundred and forty-six snags, stumps, and logs, 5,247 overhanging and submerged trees, 22 cubic yards of sand, and the upper works and machinery of the steamer Boston were removed during the year in the above improvement. About 120 miles of the river, from the mouth up, has now been improved, giving a comparatively safe channel with a depth of 4 feet at all stages of the river.

With the appropriation made by act of Congress approved June 14, 1880, it is proposed to remove snags, stumps, and overhanging and sub-

merged trees from that portion of the river between Buzzard Bar and Half Moon Bluff, and to cut a channel 3 feet deep and 50 feet wide through the rock shoal about 4 miles below Geneva. It is proposed to apply the appropriation asked for to completing the improvement according to the adopted plan, and to extending the improvement above Geneva toward Newton as far as possible, according to the plan proposed in the report upon that portion of the river submitted March 3, 1880.

The cost of improving that portion of the river below Geneva will exceed the original estimate about $10,000, the explanation of which is as follows: The original estimate was based upon the supposition that the work would be pushed through in a year or two at most, whereas the appropriations as made have already extended the work six years, requiring the expenditure of a large percentage of each appropriation, since the first, to clear the portion of the river previously worked of snags and other obstructions which annually form in the river.

A great deal of work has also been done not contemplated in the original estimate, which assumed a depth of 7 feet way through, which was not found to exist, and which only estimated for an improvement for the trade on the river at that time, whereas the increase since has required a more complete improvement.

There is no doubt, in fact, that more work has been already done, and the river is now in better condition, than was contemplated by the report upon which the estimate was based.

The improvement of this river will not be permanent in its character, but will require an expenditure of about $2,000 each year to keep it in good order.

Since the improvement of the river began, and probably in a great measure owing to its partially improved condition, there has been a marked increase in the commerce carried on between points on the river and Pensacola.

As to the amount of commerce to be benefited by this improvement, it is reported that there are now 25,000,000 cubic feet of timber annually transported down the river, and miscellaneous stores, cotton, and grain, up and down, probably of nearly equal value.

This work is situated in the collection district of Pensacola, Fla., and Pensacola is the port of entry.

Revenue collected during fiscal year ending June 30, 1880, $67,335.79.

Money statement.

July 1, 1879, amount available	$5,148 87	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$12,148 87
July 1, 1880, amount expended during fiscal year		4,101 34
July 1, 1880, amount available		8,047 53
Amount (estimated) required for completion of existing project		96,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

EXAMINATION OF CHOCTAWHATCHEE FROM GENEVA TO NEWTON, ALABAMA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., March 3, 1880.

SIR: I have the honor to submit the following report upon the examination of Choctawhatchee River from Geneva to Newton, Ala., authorized by act of Congress approved March 3, 1879:

After completion of the field work on Pea River the examination of this portion of the Choctawhatchee was commenced at Newton, Ala., and continued to Geneva, Ala., a distance of about 40 miles by river. The river for about 10 miles below Newton runs over a series of rock shoals, then for about 20 miles through a low, swampy country, and is made impassable by the accumulation of snags and drift-logs. For the remaining 10 miles the river is nearly free from obstructions until the rock shoal near Geneva, about half a mile long, is reached. To improve this section of the river (from Newton to Geneva) for navigation by light-draught boats during the season of high-water, lasting about six months during each year, besides the removal of snags and logs, the construction of three locks and dams would be necessary. The cost of the whole improvement is estimated at $78,500.

The probable commerce to be benefited by this improvement being comparatively small, and naturally passing over the lower portion of the river to reach a market, I would respectfully recommend that it be deferred until that of the river below Geneva is completed.

The report of Mr. Haines, assistant engineer in charge of the examination, and a tracing of index map are herewith transmitted for detailed information.

Respectfully submitted.

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. HIRAM HAINES, ASSISTANT ENGINEER.

MOBILE, ALA., *October* 18, 1879.

SIR: I have the honor to submit the following report of my examination of the Choctawhatchee River, from Newton to its confluence with Pea River at Geneva, Ala.

The length of the river from Newton to its junction with the Pea River is about 40 miles. In the first 10 miles of the descent, or to the mouth of Little Choctawhatchee Creek, the obstructions consist chiefly of rock shoals and fish-trap dams, comparatively few fallen trees and snags being observed. The following 20 miles the river runs through a low, swampy country; numerous cut-offs occur, dividing and withdrawing from the volume of the main stream, which becomes tortuous, shallow, and often so filled with snags and drift as to be impassable. In the remaining 10 miles but few obstructions of any kind occur, the shoal commencing just below the mouth of Double Bridge Creek and extending for nearly half a mile, and within a few hundred feet of the mouth of Pea River, being the most extensive and formidable.

The following is an estimate of the cost of improving the Choctawhatchee River from Newton to Pea River to render it navigable for barges and small steamboats for six months of the year:

For the construction of three dams and locks of crib-work for overcoming the shoals and falls between Newton and the mouth of Choctawhatchee Creek, at $15,000 each	$45,000 00
For removing snags, fallen trees, and fish-traps in the first 10 miles	3,000 00
Ditto next 20 miles	10,000 00
Ditto next 10 miles	2,000 00
Snag-boat	7,000 00
	67,000 00

500 linear feet dike, at $5	2,500 00
500 linear feet brush dam, at $3	1,500 00
Dredging and rectification of channel	7,500 00
	78,500 00

The same remarks in regard to agricultural productions and the improvement necessary apply to this river as to the Pea River. I consider the construction of the dams and locks inadvisable at the present time. There are from 1,500 to 2,000 bales of cotton sold annually in Newton, which would probably represent the amount of this product that would seek transportation down the Choctawhatchee were it improved. The field notes give in detail the observations made in the examination.

Very respectfully, your obedient servant,

HIRAM HAINES,
Assistant Engineer.

Bvt. Maj. A. N. DAMRELL,
Capt., Corps of Engineers, U. S. A.

K II.

IMPROVEMENT OF ESCAMBIA RIVER, ALABAMA AND FLORIDA.

An examination and partial survey of this river was made under authority of act of Congress approved June 18, 1878, from the Alabama and Florida State line to its mouth.

The report on the same is contained in Annual Report of the Chief of Engineers for 1879, pp. 852 and 856.

The plan adopted for the improvement was to dredge a channel through the bar at the mouth of the river, 150 feet wide and 5½ feet deep at mean low-water, remove the snags and overhanging trees the whole length of the river, and construct a few dams and wing-dams where the channel is divided or much widened, and shore protection where the banks show an inclination to wash and cave.

The first appropriation for this work, $8,000, was made by act of Congress approved June 14, 1880.

It is proposed to use this amount in the dredging mentioned above by contract, if reasonable bids can be obtained. It is proposed to use the amount asked for in continuing dredging and carrying on the other work specified in the plan. The work would not be permanent in its character, but would require more or less dredging and snagging from year to year.

The commerce to be benefited is confined to lumber, about 5,000,000 feet of which, including hewn and sawed, are annually transported down the river.

This work is situated in the collection district of Pensacola, Fla., and Pensacola is the port of entry.

An appropriation of $17,000 is asked for fiscal year ending June 30, 1882.

Money statement.

Amount appropriated by act approved June 14, 1880	$8,000 00
July 1, 1880, amount available	8,000 00
Amount (estimated) required for completion of existing project	17,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	17,000 00

K 12.

IMPROVEMENT OF ALABAMA RIVER, ALABAMA.

The examination and partial survey of this river was provided for by act of Congress approved March 3, 1875. It was made during the months of July to October, 1875.

The report was made on the 8th of March, 1876, and is contained in the Annual Report of the Chief of Engineers for 1876. The project adopted was to obtain a channel 200 feet wide and 4 feet deep at low-water.

The estimated cost was		$229,741
The appropriations made for the work are as follows:		
By act of Congress approved June 18, 1878	$25,000	
By act of Congress approved March 3, 1879	30,000	
By act of Congress approved June 14, 1880	25,000	
		80,000
		149,741

Work upon this improvement was commenced in the fiscal year ending June 30, 1879.

The work accomplished during that year was the closing of the cut-off about 25 miles above the mouth by a brush and stone dam, which, however, was not quite completed, and the removal of 320 snags, clearing the river for about 50 miles from its mouth. During the year ending June 30, 1880, the dam across the cut-off was completed. Its length is 1,125 feet and height from 8 to 18 feet, width on top of 20 feet: about 150 tons of stone, obtained 60 miles up the river, were used in capping the central portion. A wing-dam 350 feet long was extended from the dam into the river to prevent scour along its base, and also to concentrate the current so as to scour out a channel through the bar in the river below. The dam at the last examination was reported tight, and 5 feet depth at low-water on the bar in the river below. At Haynes' Island, 94 miles higher up, 20 miles above Claiborne, 3 chutes were closed by brush dams, 2 wing-dams were built, and all snags removed from the channel; 2,482 linear feet of dams and wing-dams were required at this point, and the channel was deepened by them from 2½ feet to 4 feet at low-water. At Erwin's Bar, 115 miles above Mobile, 2,400 piles were collected; but a rise in the river prevented the prosecution of the work. At Hobbs' Bar, the left-hand chute was closed by a stone dam (pierre perdue) 435 feet long and 6 feet high. There were used in its construction 600 cubic yards of rock and 800 cubic yards of gravel. The depth of the bar in the main channel was deepened from 3 feet to 4 feet. At Yellow Jacket Bar the right-hand chute was partially closed, 600 cubic yards of rock being placed in position. At Gardner's Island, 16 miles above Selma, and one of the worst places on the river, snags were removed and mattresses of cane and piles were collected and prepared for closing the left-hand chute.

Four hundred and ninety snags were removed from the river during the season.

From December 7, 1879, to May 17, 1880, work was stopped on the river by high-water, during which time the boats were docked, calked, repaired, and put in good order.

The following table shows the amount and character of work accomplished from the commencement to the end of the fiscal year ending June 30, 1880:

	Miles from Mobile.	Brush dams, linear feet.	Rock dams, linear feet.	Original depth.	Present depth.	Number of logs removed.	
Below cut-off						5	
Cut-off	70	1,740		2′ 5″	5′		
Cut-off to Erwin's						344	
Erwin's	115			2′ 5″			2,400 piles delivered.
Erwin's to Haynes' Island						130	
Haynes' Island	164	2,482		2′ 5″	4′		
Haynes' to Hobbs'						133	
Hobbs'	202½		435	3′	4′		
Yellow Jacket	203½		400	2′ 5″			Unfinished.
Yellow Jacket to Kaiser's	265					198	
Gardner's Island	320			2		125	Unfinished.
		4,222	835			935	

It is proposed to use the funds available during the coming fiscal year—

1st. To complete the improvements at Erwin's, Yellow Jacket, and Gardner's Island.

2d. To remove snags and sunken logs from the channel as high up as Montgomery.

3d. To survey as many bars as opportunity permits. (This work is quite essential, because out of 77 bars reported in the survey of 1876 as requiring other work than snagging only 7 were surveyed and mapped.)

4th. To improve such bars as surveys or information from pilots may indicate as being most troublesome to navigation. The stage of water in the river from time to time, and other circumstances that cannot be foreseen, make it impracticable to particularize more definitely a scheme of operations for the ensuing year.

The appropriation asked for for the fiscal year ending June 30, 1862, it is proposed to expend in continuing and perfecting the work of improvement on the plan recommended in the annual report for 1876 as now partially carried out. As far as practicable, it is designed to remove obstacles and improve bars in the order of their importance, such a course being most acceptable to steamboatmen.

The amount required for the completion of the work as designed, exclusive of former appropriations ($80,000), is estimated at $150,000. Of this amount, $60,000 can be profitably used during the fiscal year ending June 30, 1882.

The work when completed will not be permanent, but it will require yearly removal of snags, for executing which a suitable steamboat working five months in each year at an annual cost of $8,000, will probably be sufficient.

The results effected by the work already done are, increased safety to navigation from the removal of dangerous logs; greater regularity with less time consumed in making trips during low-water; the boats now run all night, where they were obliged formerly to tie up, and greater loads are carried in consequence of deepening the water over the worst bars. Between the cut-off and the mouth—20 miles—the people were deprived

of river facilities during low-water, as the boats were then compelled to pass through the cut-off into the Tombigbee. Now that part of the river is navigable at all times, and the serious inconvenience heretofore experienced by the planters there, from their interrupted communications, has been done away with. The completion of this work will greatly extend and add to the benefits already felt from its prosecution.

The increase in the business that will result cannot be definitely stated, but on general principles it is evident that when the Alabama with a low-water volume exceeding that of the Ohio, shall be opened to safe and uninterrupted navigation, the augmented facilities for transportation, with its lessened cost, will greatly stimulate both traffic and travel on the river. New branches of trade and diversified agricultural pursuits will be encouraged, and when the improvements now in progress on the Coosa are completed the mineral resources of that region will be largely developed in consequence of the cheap and easy outlet afforded by the improved Alabama. Forty-six thousand seven hundred and twenty-three bales of cotton and other merchandise of equal value were transported up and down the river during the year.

The work is situated in the collection district of Mobile, and commences 50 miles above that port of entry.

The amount of revenue collected at Mobile during the past fiscal year was $63,946.09.

Money statement.

July 1, 1879, amount available	$33,312 32	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$58,312 32
July 1, 1880, amount expended during fiscal year		17,770 08
July 1, 1880, amount available		40,542 24
Amount (estimated) required for completion of existing project		149,741 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		80,000 00

K 13.

IMPROVEMENT OF WARRIOR AND TOMBIGBEE RIVERS, ALABAMA AND MISSISSIPPI.

I.—BLACK WARRIOR RIVER.

The survey of this river was made, in compliance with provisions of the river and harbor act of June 23, 1874, from its mouth to Locust Fork, from August to November, 1874. The report upon it was submitted January 27, 1875, and forms a part of the Annual Report of the Chief of Engineers for that year.

The project adopted was to so improve the river as to give a channel, 80 feet wide and 4 feet deep at low-water, from the mouth up to Tuscaloosa, Ala., by the removal of snags, overhanging trees, and deepening bars by the construction of dams, wing-dams, dredging, and blasting; the estimated cost of which was $151,103.

Work was commenced on this improvement in July, 1875, and was continued during low-water until September, 1879, under the following appropriations:

By act of March 3, 1875, $25,000 for the Black Warrior below Tuscaloosa, and Tombigbee below Demopolis.

By act of August 14, 1876, $15,000 for the improvement of the Warrior and Tombigbee.

By act of June 18, 1878, $40,000, $28,000 on the Warrior and Tombigbee, $12,000 on Tombigbee above Columbus, Miss.

By act of March 3, 1879, $30,000, of which sum $10,000 shall be expended on the Tombigbee above Columbus, and $20,000 on the Warrior and Tombigbee below Columbus, Miss.

By act of June 14, 1880, $47,000, of which $20,000 shall be expended on the Warrior, $12,000 on the Tombigbee between Columbus and Vienna, and $15,000 on Tombigbee below Vienna.

Of this amount $102,213.04 has been expended on the Warrior below Tuscaloosa, and the Tombigbee from Columbus to the mouth.

The work done up to June 30, 1879, on the Warrior below Tuscaloosa is as follows:

Number of bars improved to the projected depth and width 30 (former depth from 1½ to 2½ feet).

Number of bars improved but needing additional work to remove shoals found below, 8 (former depth 1½ to 2½ feet, present depth 2½ feet).

Number of logs removed, 3,911.

Number of trees cut, 2,925.

Linear feet of dams and wing-dams built, 16,077.

Linear feet of bank protection, 1,281.

The boats and outfit built and purchased have absorbed the remainder of the amount expended. No work was done on this improvement durring the last fiscal year, for the reason that complaints having been made that all the funds were being expended on the Warrior below Tuscaloosa, and Tombigbee below Columbus (which, however, the appropriations up to that time apparently implied as the locality for the work provided for), by authority of the Chief of Engineers the working force was transferred from the Warrior to the Tombigbee, and the balance of the funds retained to equalize as far as possible the expenditures on both rivers.

The improvement already effected has given 4 feet depth of water on many bars formerly impassable at low-water, and established the fact that this depth can be secured up to Tuscaloosa.

The bars on the lower part of the river not yet having been improved, prevents the full benefit from the improvement above, and gives only 2½ feet as the low-water depth throughout. This allows boats to run through to Tuscaloosa on a 2-foot rise, when formerly they were stopped at Log Shoals, 70 miles below. Light-draught boats also make trips to Candy's Landing, 25 miles above Demopolis, at all times, which was formerly impracticable.

The actual working time on this river was eighteen months.

To complete the improvement will require more or less work on about 50 bars, slight alteration and repairs to work already done, and the clearing of the river, its full length, of snags and overhanging trees which have accumulated since the work was suspended.

The work done upon this river will need annual revision. Slides are of quite common occurrence, which throw trees into the river and form obstructions. From two to three months' work of a steam snag-boat will be required every year to keep the channel clear and the work in efficient condition. An average annual expenditure of $3,000 will doubtless be sufficient for this purpose.

When the improvement is finished and navigation to Tuscaloosa made easy throughout the year, the immediate result will be an annual saving in cotton transportation, during the months of September, October, and November, of $1.50 per bale on about 15,000 bales, amounting to $22,500. The saving on return freights will raise this amount to over $30,000. At present, during the above-named months, rail transportation monopo-

lizes the business, with a charge of $2.50 per bale. When the business is competed for by both rail and river the rates are reduced to $1 per bale, and often less. The main increase in business that will result from the completion of the Warrior River improvement will be in the transportation of coal from Tuscaloosa, which, with navigation made practicable for barges, will undoubtedly become extensive and of great importance.

It is proposed to use the funds available for expenditure during the fiscal year ending June 30, 1881, in thoroughly cleaning the river of logs below Tuscaloosa, in improving the shallowest bars from Demopolis to Eastport, a distance of 50 miles, and in providing the outfit needed for this work.

The appropriation asked for for the fiscal year ending June 30, 1882, would probably be spent in continuing the improvement below Eastport, and in finishing the improvement above Finch's Ferry.

Number of bales of cotton transported down this river during fiscal year ending June 30, 1880, 15,415.

This work is situated in the collection district of Mobile, Ala., and Mobile is the port of entry.

Revenue collected during fiscal year ending June 30, 1880, $63,946.09.

II.—TOMBIGBEE RIVER.

The examination of this river, which was provided for by act of July 11, 1870, was made December, 1870, to March, 1871, from Columbus, Miss., to its mouth. The report being unfavorable and unsatisfactory, a re-examination, from Jones's Bluff, 49 miles above Demopolis, to the lower end, was made soon after, in connection with other works, and reported upon April 17, 1871.

The project was adopted in 1871, and contemplated the removal of snags at Slater's Rocks, 152 miles above Mobile, and at Ten-Mile Shoals, about 10 miles below Columbus, Miss. The removal of a wreck at Perry's Landing, dredging through the shoals at same, 127 miles, and at Osage Bar, 155 miles above Mobile, widening the channel at McGrews' Shoal, 122 miles above Mobile, and reconstructing the wing-dams at Pearson's Shoal, 213 miles above Mobile. The estimated cost was $21,500.

The first appropriation was made by act of June 10, 1872, $10,000 in amount. Work was commenced in August, 1872, at a point 102 miles above Mobile, and continued until the 18th of December, when a rise in the river compelled a suspension of operations. At a point 214 miles above Mobile 250 snags were removed from the portion of the river improved, at a total cost, for snag-boat, outfit, supplies, and labor, of $5,332.95.

The act of March 3, 1873, directed that the amount appropriated by the former act should be expended in the State of Mississippi. The work was then transferred to the charge of Major McFarland, Corps of Engineers, U. S. A. The balance of the appropriation, $4,667.05, was expended by that officer in 1873, 1874, in improving that portion of the river between Aberdeen and Bar's Ferry above, by the removal of snags, drift, and overhanging trees.

By act of March, 1875, $25,000 was appropriated for the improvement of the Tombigbee below Demopolis and the Black Warrior below Tuscaloosa jointly. By act approved August 14, 1876, $15,000 was appropriated for the Warrior and Tombigbee together. By act of June, 18, 1878, $10,000 was appropriated for the Warrior and Tombigbee. The act of March 3, 1879, appropriated $30,000, and specified that $10,000 should

be expended above Columbus and $20,000 on the Warrior and Tombigbee below Columbus. The act of June 14, 1880, appropriated $47,000, of which $20,000 was to be expended on the Warrior, $12,000 on the Tombigbee between Columbus and Vienna, and $15,000 on the Tombigbee below Vienna. Under these appropriations work was resumed on the Tombigbee in September, 1878, and has been continued to the end of the fiscal year ending June 30, 1880, during low-water, a total actual working time of ten months. During the progress of the work it was ascertained that it was possible to make a much greater improvement of this river than was originally supposed or proposed, and the first project was modified in 1879, the object of the modified project being to afford a channel of navigable width, and not less than 4 feet depth, from the mouth to Demopolis, and not less than 3 feet depth from Demopolis to Columbus, at an estimated cost of $170,000.

During the year ending June 30, 1879, Turkey Shoal was improved, by scraping and the construction of wing-dams, so as to give nearly 4 feet where there was formerly 18 inches of water. Barney's, Sellars's, and Osage bars were deepened from 2 feet to 4 feet, and works for deepening Hatcheetigbee completed. Three thousand three hundred and five linear feet of wing-dams were built in these works, and 911 logs were removed.

During the year ending June 30, 1880, work was commenced, July 7, 1879, at Peavey's; but, owing to complaints that a disproportionate amount of the appropriations was being expended below Demopolis, it was determined to commence work above. A steamboat was chartered for use as a tow-boat and transport, and on the 7th the boats left Peavey's. On the way up the river a flaw in the boiler was discovered, and the boat having proved otherwise unsatisfactory, she was sent back to Mobile and exchanged for another. This caused delay, and it was not until the 19th that the fleet reached the mouth of the Warrior, 1 mile above Demopolis. At this point work was commenced, and carried on up stream for 20 miles, ten bars being surveyed and improved in that distance. This portion of the river was found to be very shallow, the bars affording in some cases only 1½ foot of water, and the intervals between bars generally not exceeding 4 to 6 feet in depth. These shallow reaches made it necessary in some cases to extend parallel jetties considerably below the original bar in order to dissipate the material scoured out over a larger space, and thus prevent the formation of run-bars. Another force was organized at Columbus, and commenced work August 26, 1879, at Curtis Island, a short distance below Columbus, and moved down the river to "Ten-Mile Shoals," partially improving that portion of the river.

On the 23d of November work was suspended on account of high-water. The log-boat was sent to Mobile for repairs and to be laid up for the winter. The other boats—part of the original outfit, built at Tuscaloosa in 1875, at light cost, for temporary use—had become completely unserviceable. Being much decayed, they could not be caulked, and had of late been kept afloat with some difficulty. As they could neither be stored up the river nor sent to Mobile, they were, with one exception, filled with rock and utilized in jetties at Black Snake. One, the best of the lot, was started for Mobile with the log-boat; but it sunk during the first night, and was abandoned.

On the 1st of May the log-boat and a new barge were taken in tow at Mobile to be moved up to Ten-Mile Shoals, 20 miles below Columbus, Miss. This place was reached on the 11th, and work commenced on the

next day. Some days afterwards a small quarter-boat arrived from Aberdeen, and by the end of the month a full force was organized.

At Ten-Mile Shoals (so called from their length) the river meanders between low alluvial banks of light sandy soil that yields readily to the action of the current. Every bend is a caving bank, with a gravel bar opposite. As the banks recede, throwing their timber into the stream, the gravel bars advance, covering up the fallen trees, so that the river-bed, from bank to bar, is choked with logs. Navigation at low-water is, of course, impossible, and boats seldom attempt it on less than a 6-foot stage. Shoals appear at intervals, affording only 14 to 18 inches of water. These occur at the "crossings;" that is, where the current crosses over from bend to bend. In bends the water is deep, often as much as 20 feet. The improvement needed is to remove the logs, deepen the shoals, and protect the caving banks to make them permanent. To accomplish this last result the plan adopted is to build spurs of brush and gravel, secured between rows of small piles, from the top of the bank sloping down to the water and extending into it 10 or 15 feet. It is generally possible to select, as the terminus of the spur, a large root of a tree lately fallen, the trunk of which lies parallel with the bank. The logs removed from the channel are placed along the bank below the spurs, with the expectation that a deposit will take place in the eddies caused by the spurs, and in time cover the logs. When a rise in the river occurs, the banks, which are only 8 to 12 feet above low-water, are soon overflowed, and the current sweeps through the swamps, being almost destroyed in the channel. Hence, it is reasonable to suppose that the spurs will prove effective. Up to this time nearly 1 mile at the lower end of Ten-Mile Shoals has been improved according to the plan above described.

The funds available during the fiscal year ending June 30, 1881, should be used in completing the improvement of Ten-Mile Shoals, and in connection with the funds available for the Warrior, in building a steam snag and tow boat for the joint use of the Warrior and Tombigbee.

The appropriations asked for, for the fiscal year ending June 30, 1882, should be applied to the completion of the improvement between Columbus and Demopolis, and to the revision and extension of the improvement below Demopolis.

This improvement, like that of the Warrior, and for the same reasons, will need annual revision after completion; $5,000 will be a sufficient annual appropriation for this purpose. Should a steam snag-boat be built for joint use of the improvements on these rivers, she can be utilized after the completion of the work in maintaining its efficiency.

The work thus far executed on the Tombigbee improvement has greatly lessened the dangers of navigation below Jackson, and has extended low-water navigation, for light-draught boats, 100 miles.

The completion of the improvement, as contemplated, will give an uninterrupted water communication from Mobile to Columbus, Miss., a distance of 416 miles. From 60,000 to 70,000 bales of cotton are now annually taken down this river during the winter season.

With navigation open all the time, this amount will be much increased, and general traffic and travel greatly stimulated. No definite data are accessible on which to base a close estimate of the amount of business to be anticipated with an improved river. One result, however, can be confidently predicted. When a continuously open river shall be maintained throughout the year, the competition between railroads and steamboats that prevails now only in the winter and spring, the saving to the

community on a year's business, in the cost of transportation of cotton alone, must exceed $100,000.

The following tables present a detailed statement of the work done and its results:

Names of bars.	Above Mobile.	Lineal feet of brush dams.	Number of logs removed.	Number of trees cut.	Original depth.	Present depth.	Remarks.
	Miles.						
Peavy's	130	275	....	....	2′ 6″	....	Unfinished.
Hatcheetigbee	134	653	....	....	2′ 6″	3′ 6″	
Osage	152	895	....	....	2′	4′	
Sellar's	153	985	....	....	2′	3′	
Barney's	169	175	....	....	2′ 3″	4′ 6″	
Turkey Shoals	205	850	....	....	1′ 8″	3′	
Mouth of Warrior	244	305.	....	....	1′ 10″	3′ 2″	
Hancock's	246	520	....	....	1′ 10″	3′	
The Rocks	246½	541	....	....	1′ 6″	3′	
Bee Tree Island	247	322	....	....	2′	3′	
Arrington's	251	120	....	....	2′	3′	Little Bigbee.
Haunted Point	253	805	....	....	1′ 8″	3′	
Birdine	256	971	....	....	1′ 6″	3,	
Kirkpatrick's	259	135	....	....	2′ 3″	3′	
Lipscomb's Gin	260	....	....	....	2′ 3″	3′	
Black Snake	263	891	....	....	1′ 6″	3′	
Ten-Mile Shoals	395	800	....	....	1′ 4″	3′	In progress.
Total	....	9,193	1,871	250	....	....	

Name of locality.	Before work.		After work.		Pulled logs.	Felled trees.	Distance from Columbus.
	Depth.	Width.	Depth.	Width.			
	Inches.	*Feet.*	*Feet.*	*Feet.*			*Miles.*
Curtis Island	8	15	3	30	58	17	0
Huddleston's Shoals (plenty of water, trees and logs the only impediment)	....	....	....	....	44	112	1½
Butler's Shoals (plenty of water, trees and logs the only impediment)	....	....	....	....	2	4	5
Harrison's Chute	....	....	....	....	21	10	....
Ten-Mile Shoals	....	....	....	....	182	413	13
Total	....	....	....	....	307	556	....

This work is in the collection district of Mobile, Ala., and Mobile is the port of entry. Revenue collected for fiscal year ending June 30, 1880, $63,946.09.

Money statement.

July 1, 1879, amount available	$30,229 48	
Amount appropriated by act approved June 14, 1880	47,000 00	
		$77,229 48
July 1, 1880, amount expended during fiscal year		22,442 52
July 1, 1880, amount available		54,786 96
Amount (estimated) required for completion of existing project		203,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882:		
For Warrior River	$50,000 00	
For Tombigbee River	50,000 00	
		100,000 00

...US, MISSISSIPPI.

...and Columbus,
...W. McFarland,
...of Engineers,
...river for high-
...ing trees, &c.,
...00 was appro-
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...t of the river.
...ion of $12,000
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...oint northwards,
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...ned commenced clear-
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...the winter season.
...this amount will be much increased,
...estimated. No definite data are
...estimate of the amount of business
...river. One result, however, can be
...continuously open river shall be ...
...competition between railroads and steam...
...winter and spring, the ...

The appropriation asked for the fiscal year ending June 30, 1882, is proposed to be expended in preserving the improvement accomplished. It is estimated that a yearly appropriation of $2,000 will be required to keep this section of the Tombigbee River in navigable condition.

Before the commencement of this improvement all cotton and other produce had to be hauled about 20 miles to the railroad and pay high rates of freight. As soon as the river is made navigable cheap freights will increase the trade and tend to induce farmers to settle in this section of the country.

The original estimated cost of the work under existing project is $35,000.
Total amount appropriated, $30,667.05.

An appropriation of $2,000 is asked for the fiscal year ending June 30, 1882, for the preservation of the improvement.

This work is situated in the collection district of Mobile, Ala., and Mobile is the port of entry.

Money statement.

July 1, 1879, amount available	$19,148 95	
Amount appropriated by act approved June 14, 1880	4,000 00	
		$23,148 95
July 1, 1880, amount expended during fiscal year		8,072 22
July 1, 1880, amount available		15,076 73
Amount that can be profitably expended in fiscal year ending June 30, 1882.		2,000 00

K 15.

IMPROVEMENT OF NOXUBEE RIVER, MISSISSIPPI.

This examination of this river was provided for by an act of Congress approved March 3, 1879. It was made from the mouth to Macon, Miss. The report upon it was made March 6, 1880.

The plan adopted for it is to remove such overhanging trees and other obstructions on the portion of the river above mentioned as to give a navigable channel during about nine months of the year.

The first appropriation for this work ($12,000) was made by act of Congress approved June 14, 1880. It is proposed to expend this amount in removing snags and overhanging trees as far as possible with the means to give a navigable channel between Macon and the mouth of the river during about nine months of the year, or whilst the river is a little above the lowest stage. It is proposed to apply the appropriation asked for in continuing the work according to the plan specified. The work would not be permanent, but a small amount each year would be required to keep the channel clear of snags and leaning trees.

The benefit to be derived from the improvement is the saving in freight on cotton and other produce, and supplies of planters along the river, the greater part of whom are now obliged to haul them a distance of about 15 miles to stations on the Mobile and Ohio Railroad, over heavy prairie roads, and then pay much higher freights than they would have to with an open river.

The amount of the commerce is estimated at about 15,000 or 16,000 bales of cotton, and about an equal value of other products and return supplies. This may be considerably increased. The improvement of the river will in the future possibly furnish the means for supplying cheap fuel from the Sipsey coal-fields to the inhabitants of this section.

An appropriation of $25,000 is asked for fiscal year ending June 30, 1882.

This work is situated in the collection district of Mobile, Ala., and Mobile is the port of entry.

Money statement.

Amount appropriated by act approved June 14, 1880	$12,000 00
July 1, 1880, amount available	12,000 00
Amount (estimated) required for completion of existing project	53,245 25
Amount that can be profitably expended in fiscal year ending June 30, 1882.	25,000 00

EXAMINATION OF NOXUBEE RIVER, MISSISSIPPI.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., March 6, 1880.

SIR: I have the honor to submit the following report on the examination of Noxubee River, Mississippi, authorized by act of Congress approved March 3, 1879, and assigned to me by letter dated April 25, 1879.

This examination was commenced at Macon, Miss., which is considered the head of navigation, although boats have run higher up the river, as two low bridges, without draws, cross the river at this point. The distance from Macon to the mouth is 69 miles.

With the exception of a few shoals, the principal obstructions to the navigation of the river are snags, drift-logs, fish-traps, and overhanging trees. The shoals are formed of white lime rock, easily excavated and removed. The improvement of the river is practicable and comparatively inexpensive.

The direct benefits to be derived from the improvement would be, better facilities and reduced freight rates for the transportation of the produce of the country lying near the river, consisting chiefly of cotton and corn, both of which are raised in large quantities; and the prairie belt, through which the river runs, could be supplied with coal at a reasonable cost, fuel being scarce and expensive in that section of the country.

It is estimated that it would require about $65,245.25 for such an improvement as would enable light-draught steamboats to navigate the river about nine months in the year, and if the work is undertaken an appropriation of $50,000 is recommended.

With the river improved, the shipment down would amount to 10,000 bales of cotton, and up, of general merchandise, of nearly equal value annually.

The report and tracing of map prepared by Mr. J. P. Fresenius, the assistant engineer, who conducted the examination, are transmitted herewith, to which I would respecfully refer for more detailed information.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. J. P. FRESENIUS, ASSISTANT ENGINEER.

MOBILE, ALA., *February* 21, 1880.

MAJOR: I have the honor to submit herewith my report on the examination of the Noxubee River, undertaken in accordance with your instructions.

On completion of the examination of the Sipsey River, I engaged transportation at [illegible]na, Ala., for the boats and camp equipage to Macon, Miss., a distance of 38 miles,

leaving the former place November 20, 1879, and arriving at the latter on the evening of the 21st.

Macon, the county seat of Noxubee County, is situated directly on the Noxubee River, has a population of between 2,500 and 3,000, and being surrounded by a most fertile, rich, and productive prairie country, is one of the most enterprising and flourishing towns of East Mississippi. Not only are the citizens of Macon, but also the whole community living near and adjacent to the Noxubee River, deeply interested in the project of making the river navigable, and I deem it proper to state here that on my arrival at Macon I found a universal desire on the part of the community to aid and assist the undertaking of making the Noxubee River navigable, as far as practicable, for at least a great portion of the year, and I have no doubt that should work actually be commenced the government will receive all the aid that can be reasonably expected from the population living near the river.

Some thirty years ago the Noxubee River was navigated by small light-draught steamers; the last one, to the best of my information, called the Little Jimmie, sunk in 1853, and some of these boats plied as high up as 30 or 40 miles above Macon; but all were withdrawn from the river in 1856, when the Mobile and Ohio Railroad was completed to Macon. To the best of my recollection, this road obtained a grant from either the State or federal government to erect a *permanent* bridge over the Noxubee River, making Macon the head of navigation, and since then—some six years ago—the citizens of Macon and Noxubee County, Mississippi, erected a very nice iron highway bridge about 1¼ miles below the railroad bridge, a permanent structure without a draw, making it, therefore, impracticable to run boats beyond this point, even in low water. For these reasons I considered it unnecessary to extend the examination of the river beyond the town of Macon, which I took as the head of probable navigation and starting point of the survey of the Noxubee River.

Through the courtesy of the Hon. Judge Ames and several other prominent citizens of Macon I obtained a copy of the county map, showing the course of the river to the State line of Mississippi and Alabama, which not only assisted me very much, but which I found in the aggregate very correct, expediting the work very much indeed, and for which I cannot omit to express to these gentlemen my thanks. I also endeavored to get a county map of Sumter County, Alabama, but without success, and for this reason it took me more time to ascertain distances, which, however, I dare say are, in the aggregate, very correct, as I measured, wherever practicable, the points of intersection of the section lines and the river, and I do not think that the total distance of the river from Macon to its mouth, below given, will vary materially should a thorough instrumental survey be made, which I would respectfully recommend in case an appropriation be made for the improvement of this river. The Noxubee River, in comparison with the Sipsey River, offers comparatively few obstacles, and, in my opinion, can be easily made navigable, not only for the present demand of traffic but for some time to come.

The season in which, in this latitude, the usual fall freshets may be expected, had already so far advanced, and knowing the limited means at my command for the examination, compelled me to confine myself to the plan adopted on the Sipsey, viz, to reconnoiter the stream by noting every change of the course, character of the banks, and country adjacent to the river, taking soundings on an average of 75 feet, making cross-sections about every two or three miles, taking all necessary levels of fish-traps, mill-dams, and, wherever I could obtain reliable information, of high-water, all of which can be more readily seen from the accompanying field-notes, whilst the index map herewith presented gives, on a scale of 2 inches to the mile, a pretty correct view of the course of the river, and its principal tributaries. As before stated, wherever section lines or township lines crossed the river, I measured the distances to the nearest section or land corners, and I feel confident that not only the length of the river, which was computed from the accompanying map, but also the many and various bends of the river, are as correct as they could be obtained, without making an actual, instrumental, and meandering survey.

By reference to the accompanying map it will be seen that the total length of the river, from Macon to its mouth, is 69¼ miles, of which 41¾ miles are in Noxubee County, Mississippi, and the remainder, 27½ miles, in Sumter County, Alabama. Apparently in looking at the map, the course of the river is rather tortuous and crooked, but with the exception of a few instances, where either shoals are, or where drift has accumulated, the bends are in almost every instance of sufficient width, that, even in a very low stage of water, small steamboats of 3 or 4 feet draught, managed with proper care, can be easily piloted around the bends.

The reconnaissance of this river could not have been made at a more favorable time, as, from all the information obtained, in the remembrance of the oldest inhabitants, the stage of the water was lower than it had been for years, and I only regret that I was not enabled to examine the whole river at that low stage; but on December 5, 1879, when within about 20 miles of the mouth, a very severe rain-storm visited that part of the country, compelling me to lay up for two days, and causing a rise of from

to 6 feet, which prevented a thorough observation of fish-traps, dams, fords, &c., the water being all over them, and I had to locate them on the map from information obtained from parties living along the river. Also, from the same cause, I was prevented from taking accurate soundings in the above distance, as the sounding-pole at hand was only 14 feet long, and in most instances did not reach the bottom; and at the same time, with the rise of the river, the velocity of the current increased so much that soundings with a lead-line became rather unreliable. From all the information I could gather of this part of the river, viz, the last 20 miles from its mouth, no serious impediments are existing; the different fish-traps, &c., were all submerged to such a depth that no sign of their existence could be seen on the surface of the water. Here I will state that while we were on that part of the river a flat-boat, or, as they are called, keel-boats, loaded with 145 bales of cotton, and drawing about 4 or 4½ feet of water, passed us, having been loaded some 30 miles up the river from its mouth, and reached its destination without any difficulty whatever. I am informed that these boats, on the lower portion of the river, with a rise of only 2½ to 3 feet from extreme low-water, have been and are running very frequently during the cotton-shipping season, and very rarely meet with any disaster. This convinced me that, while I was deprived of seeing the lower part of the river at low-water stage, no obstructions of a serious nature can exist which would involve a heavy expenditure.

The width of the river is, in the whole, pretty uniform, though in a number of instances, at extreme low-water, in the first 10 or 15 miles, the river is not more than 40 feet wide, and at a few places where the river is contracted to even less than 40 feet. On an average, the width of river at very low water is fully 60 feet, which increases very considerably in case of even a light freshet.

I have endeavored to show on the map the different widths of the river, but the small scale I had to use prevented me from showing the difference very accurately, and I would respectfully refer you to the detailed and minute field notes, which give the width of the river on an average of every 500 to 800 feet.

In regard to the depth of the river, soundings were taken longitudinally about every 50 or 75 feet, and these soundings are also given in detail in the field notes. From these it will be seen, as well as from the various cross-sections, that though the river was very low its average depth is fully 3 feet. However, I have no doubt that by a more careful system of soundings the above figures may be found to be too much, as there are a number of shoals and a few islands where only 1½ to 2 feet of water was found. This is, however, the case in extreme low-water, and, as above stated, the stage of the river at the time the examination was made was lower than had been known for years, and I am reliably informed that such low-water stage is generally of very short duration, and hardly ever when the farming community is ready to ship their cotton crop.

The banks of the river, as nearly the greater part of all rivers in this latitude, are very uniform; that is, in respect to their formation, which is usually a bluff of greater or lesser height on one side, the opposite bank being a sloping bank of lesser elevation and subject to overflow. These features change, to more or less extent, with the river from one side to the other, so that at all times you have a high steep bluff on either one or the other side, while the other bank, in either case, is lower and sloping.

This general character is retained on the Noxubee River with great uniformity, but it is beyond a doubt more regular than I have ever experienced before; and it is proper to say that the banks of the Noxubee River, in the distance examined, are beautiful in their formation, and are almost entirely free from what is termed a swampy bank. The field notes give the detailed height and character, and almost uniformly on one side of the river would be found a perpendicular, steep, pure white limestone bluff, varying from 30 to 125 feet high, while the opposite bank would be a natural and gradual slope, averaging, at low-water, fully 14 feet high; in fact, the banks of the river are remarkably well featured, and are of very favorable material, showing in no instance any signs of washing or slides. The limestone bluffs are generally free of any growth of timber on their slope, though on top of the lime rock the best of black prairie soil is deposited, varying in depth from 4 to 20 or 30 feet. The sloping banks are of the same rich prairie soil, and are more or less densely timbered, and in a number of instances most densely and thickly overgrown with cane.

As already remarked, the soil of the country through which the Noxubee River runs is rich and fertile, and will compare favorably with any of the richest soil of Mississippi or Alabama; the land being known as the Black Prairie Belt. For this reason it is but natural that the greater part of the river runs almost continuously through plantations, though there are occasionally reaches where either one or the other bank, or in some instances both banks, are heavily timbered. The principal growth of timber is the various kinds of oak, hickory, scaly bark, walnut, and occasionally, but in rare instances, a limited amount of short-leafed pine; some birch and a number of sycamores, which, like a large quantity of overhanging willows and brush, line the sloping banks, generally close to the water's edge, forming in numerous instances, so to say, regular walls and roofing the river in. The principal produce of the above-

mentioned plantations is cotton and corn, which yield, with proper cultivation, an abundant crop, and it is safe to say that the former will average generally one-half a bale to the acre, and the latter 30 bushels per acre.

From the longitudinal soundings, as well as from the soundings taken every 10 feet at the place of cross-sectioning the river, it was found that the bed of the river is, almost in the whole distance, composed of lime rock, though, as will be seen from the field notes, in a great many places the bottom was found to be of a sandy nature or washed in black prairie soil, which, according to circumstances, changes in depth. These sand or mud deposits, however, in my opinion, are more or less of a local nature, and by using a sounding-rod and working it through these deposits, I invariably found the limestone underneath.

It will farther be seen that, as a general rule, the bed of the river is very uniform and regular, very smooth and free of deep holes and crevices, which is most plainly perceptible on the few shoals which were above water.

The nature of this limestone is that, when it is exposed to the atmosphere, it seems to harden materially, while when it is submerged under water it softens to a certain extent, which does not diminish its suitability as a foundation for any structure, as dams, &c., but which makes it comparatively easy to excavate, where necessary to deepen the channel of the river.

From my former connection with the Mobile and Ohio Railroad, I was enabled to establish a bench-mark of levels at the starting point, near Macon, Miss.

The above levels show the elevation of low-water in the Noxubee River above mean average tide-water in Mobile Bay to be 149.60, while the highest recorded shows an elevation of 175.30, giving an oscillation at that point of 25.70 feet. From the same level notes I found that the low-water in the Bigbee River at Gainesville, Ala., about 1¼ miles below the mouth of the Noxubee River, has an elevation of 102 feet above Mobile Bay, while high-water mark is 141, consequently giving an oscillation of 39 feet. To the correctness of these levels I cannot vouch, but, taking them for granted, would give the total fall of the Noxubee River, from Macon to its mouth, approximately at low-water stage, 47 feet, or about 0.7 foot per mile.

From the levels taken at the various fish-traps and dams, as far as they were in sight, it will be seen from the level field-notes that I obtained a total fall of 21 feet for a distance of 45 miles; after which I was unable to take any more levels on account of the above mentioned freshet. Assuming the *water-level* between the fish-traps and dams, these figures would give an average fall of only 0.21 foot per mile; but, from intermediate levels taken, the normal fall of the river is about 0.35 foot per mile.

The current of the river during low-water is exceedingly sluggish, and it was difficult to arrive at any reliable data of current observations, due in a great measure to the large number of fish-traps and dams, which create slackwater to a considerable distance above them. In case of even light freshets, however, the current becomes very swift, and with a rise of 5 feet the velocity of the current was found to be from 3½ to 4 miles per hour.

Owing to the limited time at my command, no accurate observations were made in regard to the average discharge of the river, but, from the data obtained, I am satisfied that a sufficient volume of water can be relied upon for at least 8 months of the year to establish a channel of 60 feet wide and 3.5 to 4 feet deep.

With the exception of Bodka Creek, which enters the Noxubee about 5 miles above its mouth, all other tributaries are of no importance, and do not contribute any amount of water to increase the river, except in times of heavy freshets.

For the first 15 to 20 miles the river is more or less obstructed by logs and drift, owing, no doubt, to its contracted width in that part of the river, which averages from 45 to 50 feet, at low water-stage. Of these logs, however, comparatively a small number are what may be called bed-logs, viz, logs resting and imbedded directly in the bottom of the river. Most of these have either fallen or slid in the river from the banks, or have been cut from the slopes and fallen in the river, resting, however, on either one or the other bank, and forming a barrier where drift will accumulate. These logs can be removed far easier than the above-mentioned bed-logs; and as they diminish considerably in number farther down stream, where they occur only occasionally, and where the river increases in width, they form only a part of the obstructions.

The next impediment to a free flow of water are the numerous fish-traps and a few mill-dams. While at Macon, I was informed by parties whose information can be relied upon that there was, or would be, a bill before the Mississippi State legislature, at its present session, to enact a law to have all existing fish-traps and mill-dams in the Noxubee River removed at the cost of the respective owners, and to make it a State offense to erect new ones. I have no doubt that such a law will be enacted, as far as the Noxubee River runs through the State of Mississippi, and as there are thirteen of these structures in the river in its course through that State it will greatly assist and diminish the cost of the improvement.

In Alabama, to the best of my information, are eight fish-traps, none of which

however, were visible on account of the rise of the river, but I have no doubt that the owners will remove them, even without the enforcement of the law in that State, provided there is a prospect of having navigation improved on that river.

The next and, in my opinion, the most important item of detriment to navigation, is the large number of overhanging and bending trees, which more or less appear on the whole length of the river. As remarked before, my time was too limited to examine any details, and it was impossible to take an accurate account of the number of trees thus obstructing navigation. I, therefore, in the annexed approximate estimate, assumed a certain amount for removing these trees, which I think will cover the cost.

Besides the above-mentioned obstructions there exist a few shoals and islands. The former are generally bare white limestone, while the latter consist, more or less, of soil, and are overgrown with willow trees and brushes.

The largest of these shoals is about 32 miles from Macon, and the place is known under the name of the Devil's Racetrack. Here the shoal protrudes above low-water fully 1 foot, and the water is forced through a very narrow channel, consequently the current is very swift and rapid; but, as already stated, this species of lime rock, as long as it is exposed to moisture, is easily excavated, and the shoals can be removed at comparatively small cost.

The few islands in the river, which are only visible in extreme low-water, are of minor consideration, and can, after being cleared of the dense growth of willow brush, easily be leveled down.

About 50 miles from Macon the river forks, and on examination of the locality I did not consider it necessary to examine both prongs, but continued on the main stream, which is plainly designated, the left-hand shoot, at the head of the fork, being completely barricaded by logs and driftwood. At the head of this cut-off a bar has already formed, and with comparatively little work a jetty or dam can be thrown across to force all the water through the right-hand shoot, or main channel.

In order to make an accurate estimate of the cost of the work it would require a more detailed survey, and the amount below given may be excessive of the actual cost. As remarked, the main obstruction consists of overhanging trees, principally sycamores, willow trees, and willow brush, which are, however, so irregular, some reaches being very densely overgrown, while others are almost entirely free from overhanging trees, that it would require considerable time to estimate on each separately, and I have therefore assumed the cost of 69½ miles, allowing so much per mile. The same is the case with sunken logs and other obstructions, which are rather numerous on the first 15 to 20 miles from Macon, but gradually become less and less as the mouth of the river is approached.

APPROXIMATE ESTIMATE.

Cutting and removing overhanging trees for 69½ miles, at $600 per mile ...	$41,700 00
Removing bed logs, drift, &c., for 69½ miles, at $130 per mile	9,035 00
Excavating shoals and islands	2,500 00
Removing fish-traps and mill-dams	3,500 00
Engineering and superintendence, including cost of an instrumental survey.	8,510 25
Total	65 245 25

The above estimate is based on a rise of 3 feet above extreme low-water.

About 21 miles from Macon the river is crossed by a wooden highway bridge, on the road from Shugulak Station, on the Mobile and Ohio Railroad, to Fairfield. This structure is about 35 feet above extreme low-water, and of course will have to be either removed or replaced by a draw-bridge, to allow boats to pass. To the best of my knowledge this bridge was built by the county, and I have no doubt that arrangements can be made with the proper county authorities to have this impediment removed or altered at the expense of the county, and for this reason I have not mentioned it in the above estimate.

The direct benefits to be derived at present from the improvement of the river consist principally in facilitating transportation of all produce raised in the vicinity of the river, with the adequate return freights, all of which has now to be transported by the Mobile and Ohio Railroad, which for some distance runs nearly parallel with the river, about on an average 15 miles west, compelling the planters to haul their produce, &c., that distance, and, as already alluded to, through a heavy prairie soil, which during wet weather is almost impassable; and I have frequently seen four and even six yokes of oxen with only one bale of cotton, weighing 500 pounds, stuck fast in the prairie mud, unable to reach the railroad.

Besides, the universal complaint through the whole country is that the charges on all kinds of freights on the railroad have been and are so exceedingly exorbitant, without any prospect whatever of a reduction, that the navigation of the Noxubee is

looked upon as one of the greatest blessings which could be bestowed upon the community living in the vicinity of the river.

One other great benefit, however, and one which I think of great importance, would be derived from the navigation of the Noxubee, and that is the question of obtaining fuel. It is but proper and just for me to state here that my attention was first drawn to this fact by Mr. W. H. Nevill, a gentleman of great energy and culture, and taking great interest in any improvement of the country. Mr. Nevill not only cultivates a very fine plantation about 45 miles from Macon, but has also on his place a small factory for wood work; and is one of the most enterprising and energetic citizens on the river, to whom I herewith tender my thanks for valuable information and courtesies received.

As already remarked, the Noxubee River runs through a rich prairie country, and is cultivated on both sides nearly its whole length, consequently the question of fuel is already a very serious one, and of course will become more so; therefore Mr. Nevill advanced the idea that, if the Sipsey River, near which coal beds are found in abundance, could be made navigable simultaneous with the Noxubee, coal could be transported from the former river to its mouth, thence down the Bigbee to the mouth of the Noxubee, and thence up the river to Macon, a distance of about 285 miles, at a reasonable expense, and Macon, having railroad facilities, be established a coal depot, from which coal could be supplied throughout the whole prairie belt along the Mobile and Ohio Railroad. I have no doubt this scheme, once properly established, would result in a considerable traffic and revenue, as boats carrying coal up the Noxubee would always find return freights of either corn, cotton, or other produce, all seeking an ultimate outlet at the Gulf.

I could not ascertain any reliable data in regard to the annual amount of produce raised along the river, but, from my former connection with the Mobile and Ohio Railroad, I remember that Macon used to ship between 8,000 and 10,000 bales of cotton, Shugulak Station, some 8 miles south, about 5,000 to 6,000 bales, and still another station, Wahalack, still farther south, from 3,000 to 4,000 bales. The bulk of these shipments, no doubt, were received from the country lying near the river, and it is but reasonable to suppose that a greater portion would avail themselves of river transportation in preference to the higher railroad freights, the former naturally always being considered cheaper than the latter.

Respectfully submitted.

J. P. FRESENIUS,
Assistant Engineer.

Bvt. Maj. A. N. DAMRELL,
Captain, Corps of Engineers, U. S. A.

K 16.

IMPROVEMENT OF PASCAGOULA RIVER, MISSISSIPPI.

An examination of East Pascagoula River was made under the act of Congress approved June 18, 1878, from its mouth to its head, the cost of which was paid from the appropriation, $10,000, made for its improvement by the same act. Report of this result was transmitted to Congress and printed in H. Ex. Doc. No. 95, Forty-fifth Congress, third session.

The plan adopted comprises the dredging of a channel 200 feet wide and 7 feet deep through the bar at the mouth of the river, and the removal of the snags and overhanging trees its entire length. The Mississippi State charter to A. A. Green having been decided as not interfering with the prosecution of the work, bids were solicited for dredging at the mouth of the river, under the balance of the appropriation above mentioned, and the appropriation of $14,000 made by act of Congress approved March 3, 1879. They were opened on the 10th of April, 1880. The lowest bidder was S. N. Kimball, and the contract was awarded to him. Work is expected to be commenced under his contract about the middle of July.

With the amount appropriated by act of Congress approved June 14, 1880, $20,000, it is proposed to continue the dredging through the bar at the mouth of the river by contract, provided reasonable bids are obtained, and to removing snags and overhanging trees as far as possible by hired labor. With the amount asked for it is proposed to complete the improvement according to the adopted plan. The improvement would not be permanent in its character. More or less dredging or snagging would be required every two or three years, the cost of which it is impossible to estimate with present data with any accuracy, but it is not thought it would be large compared with the first cost of the work.

The work is situated in the collection district of Shieldsborough, Mississippi. Pascagoula is the nearest port of entry.

The commerce to be benefited is shown by the following statement from the custom-house record:

		Tonnage.
Vessels entered from foreign countries	61	23,831
Vessels entered coastwise	23	5,301
Aggregate	84	29,132
Vessels cleared for foreign countries	64	24,523
Vessels cleared coastwise	37	8,407
Aggregate	101	32,930

Value of exports:	
12,704,636 superficial feet of lumber	$185,566 25
296,733 cubic feet of timber	38,913 92
Aggregate 13,001,369 valued at	224,480 17
Miscellaneous exports	5,268 00
Aggregate	229,748 17

Money statement.

July 1, 1879, amount available	$22,493 70	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$42,493 70
July 1, 1880, amount expended during fiscal year		69 50
July 1, 1880, amount available		42,424 20
Amount (estimated) required for completion of existing project		11,306 30
Amount that can be profitably expended in fiscal year ending June 30, 1882		11,300 00

Abstract of bids received and opened April 10, 1880, for dredging at the mouth of the Pascagoula River, Mississippi.

No.	Name of bidder.	Price per cubic yard.	Time of commencing work.	Time of completing work.
1	George C. Fobes & Co	$0 35.3	On or before the 1st day of July, 1880.	On or before the 1st day of July, 1881.
2	James E. Slaughter	33.9	On or before the 1st day of July, 1880.	On or before the 1st day of May, 1881.
3	S. N. Kimball	32.25	Within 90 days after the contract is entered into.	Nine months after commencement of work.

K 17.

EXAMINATION OF CHARLOTTE HARBOR AND PEAS CREEK, FLORIDA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., March 10, 1880.

SIR: An examination of Charlotte Harbor and Peas Creek, Florida, was authorized by act of Congress approved March 3, 1879, and assigned to me by letter dated April 25, 1879.

This examination was put under the immediate charge of Mr. J. L. Meigs, assistant engineer, who, upon the completion of the examination of the Withlacoochee River, proceeded to Fort Meade, which was considered the highest point to which the present wants of the trade would require any improvement to be carried. The field work was commenced on October 14, 1879, and continued to the mouth of the river, at Hickory Bluff, an estimated distance of 160 miles.

The examination was made with a view to improving the river for high-water navigation, lasting about nine months of the year.

The principal work found necessary is between Fort Meade and McClelland's Ford, and consists in the removal of overhanging trees and snags and loose rocks from the rock shoals at Kendrick's, Brooker's, Fishtrap, and Fort Hartsuff; comparatively few logs will have to be taken out below that point, the channel being much wider and deeper.

At the commencement of the examination of this river heavy rain-storms set in, and a rise of several feet prevented the work being done as accurately as was desirable, but sufficient data were obtained for an approximate estimate of cost of improvement.

After completing the examination of Peas Creek, that of Charlotte Harbor was commenced. The principal commerce carried on in the harbor consists in the export of cattle to Cuba and oranges to Cedar Keys.

Vessels drawing 8 feet of water can load at Knight's Pier, on the north shore, about 1½ miles below Hickory Bluff, and go to sea without difficulty through Boca Grande Pass, while vessels of lighter draught have four other outlets, which they make use of according to prevailing winds and draught of vessel.

As the present commerce is carried on by vessels to suit the depth of these channels, and are of sufficient capacity to accommodate the present wants of the trade between Cuba and Cedar Keys, an improvement of Charlotte Harbor does not seem to be required at present.

The approximate estimate to make Peas Creek navigable for light-draught boats, during about nine months of the year, from its mouth to Fort Meade is $17,000, and should the work be authorized I would recommend an appropriation of that amount.

It is expected that upon the completion of this improvement the country along and adjacent to the river will increase in population, and that before many years further improvement may become necessary.

No reliable statistics could be obtained as to the present commerce of the river, nor to what extent the same would be benefited by the proposed improvement.

The report of Mr. J. L. Meigs and tracings of index maps are forwarded herewith for detailed information.

Respectfully submitted.

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. J. L. MEIGS, ASSISTANT ENGINEER.

MOBILE, ALA., *January* 25, 1880.

SIR: In accordance with your letter of instructions of August 15, 1879, an examination was made of "the best approaches to the mouth of Peas Creek from Gasparilla Pass and Boca Grande; the best approaches to Punta Rosa from Boca Grande and Boca Ciega, and the best route from the mouth of the Caloosahatchee, along the east shore of Charlotte Harbor, to the mouth of Peas Creek." The appropriation being limited, it was decided to examine the more important lines of communication first.

I would respectfully submit the following report on examination of Charlotte Harbor and Peas Creek, Florida:

PEAS CREEK, FLORIDA.

The party sailed from Cedar Keys for Tampa on October 8, 1879, and arrived on the 10th. After procuring supplies and means of transportation, the march thence to Fort Meade, in Peas Creek, was begun October 14. Progress was much impeded by heavy rains, high streams, submerged lowlands, and a broken bridge; so it was not until October 20 that we arrived at Fort Meade Ferry.

With great difficulty the necessary lumber was obtained for building a skiff 3½ by 14 feet, and a flat-boat 8 by 20 feet, for the purposes of the examination. There was no sawmill in operation in that region, and it was only through the zealous help of the citizens that we succeeded in building the boats.

Frequent heavy rains fell during the building of the boats and after our departure from Fort Meade, not terminating until October 31, after which the weather became fair and settled. At Fort Meade the river was seven feet higher than ordinary low-water stage, and throughout the entire examination we labored under the very great disadvantage of searching for submerged shoals and obstructions. The situation of these, however, with reference to sections and townships, was ascertained from Mr. J. E. Roberson, county surveyor of Polk County, and from citizens long resident in the region bordering on the river, and who had opportunity for many years of seeing and examining the river at all stages of the water. Information was also obtained in regard to the material of the river-bed at the different shoals, the height of the usual summer water, obstructions from submerged rocks and accumulations of logs, and from sand-bars. Added to this are the facts ascertained by constant soundings and observations of different channels, varying width, and obstructions from overhanging trees and limbs.

The result of these inquiries and of the examination are presented in tabular form, for convenient reference, as follows:

Peas Creek measurements and observations.

Division of river.	Subdivision of river.	Distances measured on map.	Widths.	Depths of ordinary low-water.	Banks to be cleared of overhanging trees and limbs.	Snags to be removed.	Remarks.
		Miles.	*Feet.*	*Feet.*	*L. feet.*		
I.—From Fort Meade Ferry, about 1,100 feet north of south line of section 26, township 31 south, range 25 east, to Choconicla road-crossing, 230 feet below north line of section 15, township 33 south, range 25 east.	River basin	0.90	30 to 90	1.8 to 6.5	4,800	6	The length of Division I is from 2 to 2½ times as long as represented on plats of United States land surveys, and this remark is generally true of the distances obtained from measurements on the land plats.
	River basin to Kendrick's Shoal, just above the mouth of Bowleg's Creek.	1.53	40 to 70	1 to 4	8,600	51	
	Kendrick's Shoal	0.09	50	0.5 to 2.5	475	....	The bed of this shoal is soft limestone, full of crevices, and easily removable by sledges and bars.
	River basin, from Kendrick's to Brooker's Shoal, near middle of section 15, township 32 south, range 25 east.	1.85	45 to 70	1 to 7	19,100	21	
	Brooker's Shoal	0.11	60	1 to 2.5	600	....	
	River basin, from Brooker's Shoal to point about 700 feet above south line of section 22, township 32 south, range 25 east.	1.87	45 to 90	2.5 to 7	14,450	30	
	River basin, from point last named to Choconicla road-crossing.	4.68	45 to 90	4 to 8	7,800	6	
II.—From Choconicla road-crossing to Bostick's Landing, at north line of section 28, township 34 south, range 25 east.	River basin, from Choconicla road to head of shallow below an island.	0.75	80 to 90	5.2 to 7.2	....	2	
	Shallows	0.21	70 to 100	3.7 to 7.2	....	....	
	River basin, from foot of shallows to road-crossing, ½ mile south of north line of section 27, township 33 south, range 25 east.	1.59	65 to 100	4.7 to 7.2	1,600	7	
	River basin, from last-named point to Fishtrap Shoal, about 1/10 mile north of south line of section 2, township 34 south, range 25 east.	3.16	80 to 110	2.2 to 7.4	1,150	4	Within this basin, and about one mile above Fishtrap Shoal, a ledge of rock projects from west bank within 30 feet of east bank at low-water; water 2½ feet deep near east bank.
	Fishtrap Shoal, 60 feet long	0.02	90	1	....	2	A smooth rock ledge extending from bank to bank.

	From Fishtrap Shoal to English's Ferry, called by some Fort Hartsuff Shoal, about 0.07 mile below east line of section 10, township 34 south, range 35 east.	1.00	70 to 90	5.4 to 7.4	....		
	River basin, from English's Ferry to Fort Hartsuff Shoal, near southwest corner of section 11, township 34 south, range 25 east.	0.40	85 to 120	4.9 to 7.4	....	8	
	Fort Hartsuff Shoal	0.25	50 to 70	1 to 6.7	1,400	....	Soft limestone bottom.
	River basin, from shoal to Bostick's Landing	2.47	50 to 120	5 to 7.5	750	1	
	River basin, from Bostick's Landing to Sand Shoal, near southwest angle of section 28, township 34 south, range 25 east.	1.31	105 to 150	6.2 to 7.4	400	1	
	Sand Shoal	0.27	80 to 110	0.5 to 7	300	2	
	River basin, from foot of last named shoal to Three River Shoal.	1.06	70 to 150	3.4 to 7.4	450	6	
III.—From Bostick's Landing to McClelland's Ford, about $\frac{1}{10}$ mile south of north line of section 19, township 35 south, range 25 east.	Three River Shoal	0.31	30 to 70	0.5 to 6.5	....	3 28	This shoal extends throughout the left of these channels which the river here takes. It is avoidable by opening the middle of these, now obstructed for 350 feet by an accumulation of logs.
	Thence to Horseshoe Bend, about $\frac{12}{100}$ mile due west, from northeast corner of section 6, township 35 south, range 25 east.	1.12	50 to 250	3.8 to 7.8	3,900	33	
	Thence to McClelland's Ford	3.67	35 to 120	1.7 to 7.7	5,800	35	Within this subdivision are two sand shallows, 250 feet and 200 feet long respectively. The narrow width is that of a lagoon channel at one point only.
IV.—From McClellan's Ford to mouth of Tsala-apopka Creek, about $\frac{1}{4}$ mile south of north line of section 17, township 36 south, range 25 east.	River basin, comparatively clear of obstructions and deep.	5.75	50 to 150	4.8 to 8.5	3,600	38	
V.—From mouth of Tsala-apopka to south line of section 12, township 37 south, range 24 east.	River basin	8.06	100 to 300	4.5 to 8.5	50	29	
VI.—Thence to Dishong's Ferry, on section 22, township 38 south, range 24 east, midway between north and south lines of the section.	River basin	9.58	100 to 300	3.8 to 8.8	400	32	
VII.—From Dishong's Ferry to head of a series of shallows about $\frac{1}{2}$ mile north of south line of section 11, township 39 south, range 23 east.	River basin	8.00	100 to 300	6 to 9	....	52	

Peas Creek measurements and observations—Continued.

Division of river.	Subdivision of river.	Distances measured on map.	Width.	Depths of ordinary low-water.	Banks to be cleared of overhanging trees and limbs.	Snags to be removed.	Remarks.
		Miles.	*Feet.*	*Feet.*	*L. feet.*		
VIII.—From head of shallows last named to south line of section 34, township 39 south, range 23 east.	Series of shallows	0.77	150 to 280	1.5 to 8.5	....	...	
	River basin to head of Bangu's Shoal	0.48	160 to 240	2.5 to 9	....	...	
	Bangu's Shoal	0.09	200	1.8 to 4.5	....	...	
	Basin of deeper water extending to head sand shoal above Old Fort Winder.	1.78	150 to 300	2 to 9	....	4	
	Sand shoal above Old Fort Winder	0.17	250 to 320	1 to 2.5	....	...	
	Basin of deeper water	0.24	150 to 210	4 to 9	....	1	
	Sand shoal	0.16	250 to 300	1 to 3.25	....	...	
	Deeper water to point below New Fort Winder	0.27	250 to 300	2.3 to 5.3	....	...	
	Sand shoal	0.06	450	1 to 3	....	...	
	Basin of deeper water from foot of shoal last named to south line of township 39 south, range 23 east, at the head of Hunter's Creek.	0.86	290 to 600	2.8 to 9	....	1	Hunter's Creek is the left-hand or eastern of two channels into which the river is here divided.
IX.—From head of Hunter's Creek to west boundary of township 40 south, range 23 east; Hickory Bluff.	River basin from head of Hunter's Creek, following right channel of river, to head of Hughes's Bar.	4.66	260 to 900	3.9 to 12.9	....	...	The narrow width is that of a channel between the shore and an island.
	Hughes's Bar, at head of estuary of the river, on south half of section 22, township 40 south, range 23 east.	0.20	900	3.7 to 4.7	....	...	The distance given is that passed over by a vessel crossing the bar.
	From Hughes's Bar to Hickory Bluff	5.00	450 feet to 1.8 miles.	4.8 to 13	....	...	The length of the river from Fort Meade Ferry to the west boundary of township 40 south, range 23 east, by map measurement, is 74.91 miles. This is erroneous; it is more nearly 160 miles.

It should be remarked that the distance from point to point given in the preceding tabular statement from measurements made on the plats of the government land surveys do not correspond with the actual distances between these points. Observation has shown in the cases of Withlacoochee River and Peas Creek, that the meanderings of these streams are very inaccurately represented in these plats, and that the actual distances between points are from 2 to 2½ times greater than they appear on the land plats. This must be borne in mind in future efforts to identify localities here spoken of. The position of a submerged shoal on a section is given as accurately as the information and soundings enabled, but the *distance* of its position from a given boundary of the section, as measured on the map along the river course, will be found much less than the truth.

Peas Creek (Talakchopko, Hatchee, or Peaseating Creek) rises in the northeastern part of township 30 south, range 26 east, and flows northwestward and westward to the middle of section 33, township 29 south, range 25 east, where it makes a junction with Saddle Creek, flowing southeastward from Lake Hancock. Thence its course is southwest to Hickory Bluff, where it empties into Charlotte Harbor, making about 15 miles of westing and 66 miles of southing. It is fed by numerous lakes in the central part of Polk County. The principal tributaries in the east are Little Charley, Tsala-apopka, Josh. and Prairie creeks; and on the west, Saddle, Whitten, and Chilocolatchee creeks. Besides these streams, wide areas of swamp and hammock lands immediately bordering the river, and of the more elevated adjacent pine lands, are covered during the rainy season in July and August with shallow pools of water, which is discharged for the most part into Peas Creek. The stream therefore exhibits much variation in its stages of water, the range between extremes at Fort Meade being about 17 feet.

According to the most reliable information, it will be safest to regard the period of low-water as extending from January 1 to July 1, during which time the river could not be *regularly* navigated by vessels of 2 feet draught. At its lowest stage the stream in the channels around the bends contracts to a mere thread of water, while on the few rock and sand shoals that extend across the channel from bank to bank the water covers the entire river bed, but is too shallow to carry a skiff drawing even 6 inches. Navigation must at such times be suspended, as on most of the rivers of the South and West. There is, however, a very general agreement in opinion among old residents that the river can be constantly navigated by vessels of 14 to 24 inches draught during the six months following the beginning of the rainy season, but in order to do this overhanging trees and limbs that would obstruct passing vessels must be removed from the banks, and all masses of rock, snags, and accumulation of logs must be taken from the channel. To this extent it is respectfully recommended that the navigation of Peas Creek be improved.

In years of unusual rainfall, like 1878 and 1879, such vessels might ply regularly between Hickory Bluff and Fort Meade during *nine* months of the year.

While many believe that Peas Creek can be rendered navigable from Hickory Bluff to Barton, yet the general conviction is that the wants of the country will be satisfied by opening to navigation to Fort Meade. The more valuable lands for agricultural purposes lie along the river, and the bulk of the population engaged in agriculture is settled there. Elsewhere, on both sides of the river, the population is sparse, and engaged chiefly in cattle raising. There are many plantations of orange trees in Polk and Manatee counties within easy distance of the river, the produce of which cannot be hauled to Tampa, Manatee, or Hickory Bluff for export, but must have outlet by Peas Creek to Hickory Bluff. Thence to the Gulf, by way of Charlotte Harbor and Boca Grande, navigation by vessels of 8-feet draught is constant and unobstructed. Through this channel of communication, then, not only could the yield of the numerous orange groves be sent to a market economically, but the people could obtain, cheaply and certainly, their necessary supplies of goods and groceries.

The greater part of the work of improvement must be done on the upper river, between Fort Meade and McClelland's Ford. This part of the river being comparatively narrow and crooked, the obstructions from overhanging trees, and from accumulation of logs in the channel, is greater than on the lower river. Here, also, the four rock shoals occur, Kendrick's, Brooker's, Fishtrap, and Fort Hartsuff. Their beds are composed of soft limestone rocks, lying ragged and detached, or separated by crevices running in all directions. The masses are generally much less than a cubic yard in volume, and are easily removable by the use of crowbars and sledges. At the extreme low stage the water runs in rivulets between the rocks. These being removed and so disposed of as to confine the stream to a single channel, the navigation of the rock shoals will be relieved of all danger during the high-water period, and the depth will be as great as can be obtained without a resort to more costly work, which the present needs of the country do not justify. It is much regretted that during our examination high-water rendered impossible a careful survey of these four shoals, and an accurate estimate of the cost of removing the detached and projecting rocks that are scattered over their beds.

The accompanying estimate is only approximate, but, it is believed, will be a safe guide to a first appropriation for rendering the river navigable during the half year following the setting in of the rainy season.

In the lower river, between McClelland's Ford and Hickory Bluffs, there are no rock shoals, though many embedded logs must be removed from the channel between the mouth of Tsala-apopka Creek and Johnson's Ferry (situated on the northwest quarter of section 6, township 39 south, range 24 east).

The most serious difficulty to navigation is Hughes's Bar, lying at the head of the estuary of the river. This is a sand-bar over which, at high tide, vessels of 6-feet draught now pass, landing freights for Fort Ogden at the head of Hunter's Creek. Though this bar would require dredging to allow of the passage of such vessels at lower stages of the tide, yet the traffic does not justify the improvement at present.

The following is an approximate estimate of the cost of the proper improvement:

Estimate of the cost of improving the navigation of Peas Creek.

Division of river.	Quantities and price.			Cost of work.	Remarks.
	Rock excavation.	Banks to be cleared of overhanging trees, &c.	Snags to be removed.		
	Cubic yds.	*Linear feet.*			
I	4,066 at $1	55,825 at 1½ cents	114 at $10	$6,043 87	
II	1,071 at $1	4,900 at 1½ cents	19 at $10	1,334 50	This includes the cost of removing a projecting ledge of rock 1 mile above Fishtrap Shoal.
III	....	10,850 at 1½ cents	112 at $10	1,282 75	
IV	....	3,600 at 1½ cents	38 at $10	434 00	
V	....	50 at 1½ cents	29 at $10	290 75	
VI	....	400 at 1½ cents	32 at $10	326 00	
VII	....	....	52 at $10	520 00	
VIII	....	....	6 at $10	60 00	
IX	....	....	....	....	
I-VII	....	....	Accumulation of logs in bed of river, visible at low-water, 180 in number.	3,600 00	The number of these accumulations is given upon the authority of persons who had descended the river.
	Add for engineering and contingencies.........			2,778 27	
	Total...................................			16,669 64	

CHARLOTTE HARBOR, FLORIDA.

Preparations for the work were made immediately after the completion of the Peas Creek examination on November 6, 1879. It was determined to mark the more important channels by substantial stakes, which would not only be useful as signal poles in determining the position of the channels, but would prove a great aid to the navigation of the harbor. The schooner Jimmie, commanded by Capt. W. D. Collier, was chartered, both the kind of service and the seas sometimes encountered in the harbor requiring a more substantial vessel than an open sail-boat. A supply of pine poles measuring from 5 to 8 inches in diameter and 20 feet in length was taken on board, and the vessel sailed from Hickory Bluff on November 10 to begin the work.

From Hickory Bluff to Boca Grande.—About one-third of a mile east of the west line of section 25, township 40 south, range 22 east, and on the north shore of the estuary of Peas Creek, is Knight's Pier, a pile-work 1,940 feet long, built for the shipment of cattle. This place is commonly called Hickory Bluff, though the latter is situated 1¼ miles above it on the same shore. About 2,500 cattle are annually exported from this point to Cuba in schooners of 8-feet draught, carrying cargoes of 150 to 200 cattle each.

Schooners of 6-feet draught also ply between Hickory Bluff and Cedar Keys. These vessels usually pass a mile westward of Punta Gorda, about 2½ miles southeastward of Cape Hayes, and thence steer directly to Boca Grande. The depth of water at the head of Knight's Pier is 7 feet at mean low tide, though 8 feet might be obtained by extending the pier 280 feet farther. Such vessels can easily reach the pier when light, but usually load and depart at high tide. With this exception, the cattle vessels experience no difficulty in the navigation between Hickory Bluff and Boca Grande, even at low stages of the tide. The edge of the sand-bar extending south-

eastward from Cape Hayes was first traced by careful soundings, and a pole marking the southeast point of the bar was set in water 7 feet deep at mean low tide. This pole bears from the cape south 34° 10′ east (true), and is distant 1.95 miles. Subsequently the sand-bar off the shore of Punta Gorda was sounded, and a stake marking its eastern edge was set, bearing south 87° 5′ west (true) from the extreme western point of Punta Gorda, and distant 2,916 feet. The depth of water here is 11 feet. No other stakes were found necessary on the route, and the whole was then carefully sounded.

The depths from the head of the Hickory Bluff pier to the Punta Gorda stake range from 7 to 11¼ feet at mean low-water; thence to the stake off Cape Hayes from 7 to 19 feet; and thence to the middle of Boca Grande entrance from 7 to 50 feet. It should be added that the 7 feet depth last given was found near the Cape Hayes stake. There is ample depth of water in the usual track of vessels one-half mile eastward of the stake. Two buoys might be placed, one off Cape Hayes and the other off Punta Gorda, but no dredging or other engineering work is required in the approach to the mouth of Peas Creek from Boca Grande.

From Boca Grande to Punta Rosa.—Next in importance is the line from Boca Grande to Punta Rosa. A schooner of 6-feet draught plies regularly between Cedar Keys, Punta Rosa, and Fort Myers, and others make occasional trips. In good weather, when going south, they usually pass by Boca Grande, coast along the west shores of Captiva and Sanibel islands, double the southeast extremity of the latter, and thus approach Punta Rosa. But when the weather is threatening they enter Boca Grande and follow the east coast of La Costa Island, hugging Punta Blanco; thence they pass between Useppa and Palmetto islands, and steer to a point 1 mile east of Boca Captiva, thence to a point midway between Loggerhead and Sanibel islands; thence they enter the sound between Sanibel and Pine islands, following a somewhat tortuous channel to a point 1 mile west of the southeast extremity of Sanibel Island, whence their course is northeastward to Punta Rosa. By this route, too, these vessels generally return from Punta Rosa to Cedar Keys, and always do in bad weather, the sea being comparatively safe. This route is sometimes followed also by schooners carrying to Cuba the produce of mullet fisheries, established and carried on by Cubans; one on the northeast shore of La Costa Island, within half a mile of Boca Grande, and the other on the northeast shore of Captiva Island near Boca Captiva. These schooners are from 3 to 4 feet draught, and find abundant water at low tide.

This line was carefully examined by numerous soundings, made both from the deck of the schooner and in small boats, with a view to find the edges of the channel. These were then marked by occasional stakes set alternately on the starboard and port sides of the channel. We then sailed over the entire line from Boca Grande to Punta Rosa, sounding at regular intervals, as far as possible, on a course taken midway between the stakes. Though the channel is somewhat tortuous, yet there is sea-room for tacking when necessary. Masters of vessels had complained of shallow water opposite Boca Captiva and Boca Ciega, being sometimes obliged to await high tide before they could pass these places. Much time was spent, therefore, in searching for channels in the desired direction across the long and wide sand-bars formed at these places by the inflowing gulf tide. The effort was so far successful that vessels following the line indicated by the sailing stakes will be subject to much less delay than formerly. The chief difficulty is encountered 1¾ miles northeast of the north extremity of Loggerhead Island, where for the space of a square mile or more the bed of the channel is interspersed with lumps or small hillocks varying from 25 to 50 feet in diameter, and elevated from 1 to 1½ feet above the general level of the bottom. It may be necessary in the future to dredge the channel here for 2 miles to the depth of 7 feet, but the present traffic does not justify any expenditure on any part of the line.

It would be well to renew four years hence the present sailing stakes, substituting for the pine post the more durable cabbage palmetto logs. This should not cost more than $300.

The positions of the channel-stakes were obtained by their bearings from headlands and other prominent points, situated on either side of the route. These bearings laid down on Coast Survey Chart No. 75, determined by their intersections the places of the stakes. No other mode could be pursued within the time that could be devoted to the work.

The soundings and the distances between the stakes are succinctly shown in the following table:

Nos. of stakes.	Distances.	Extreme soundings.	Remarks.
	Miles.	*Feet.*	
Boca Grande to 1.	1.80	8 to 29	Measurement begins from a point in Boca Grande entrance abreast of the northern Point of La Costa Island. The soundings are mean low-water depths.
1 to 2	.20	7½ to 8	
2 to 3	.17	8.2 to 8.4	
3 to 4	.42	8.4 to 9.4	
4 to 6	.83	8.2 to 11.2	
6 to 5	.32	9.4 to 11.9	
5 to 7	.21	9.4 to 11.2	
7 to 8	.12	10.2 to 10.9	
8 to 9	.27	11.2	
9 to 10	.41	8.4 to 10.9	
10 to 11	.58	10.7 to 13.4	
11 to 12	.29	9.5 to 11.5	
12 to 13	.09	8¼ to 8½	
13 to 14	.30	6½ to 8	
14 to 15	.76	6.3 to 7½	
15 to 24	.38	7 to 9	
24 to 23	.21	6½ to 8.8	
23 to 17	.50	8.8 to 11	
17 to 18	.28	7½ to 9½	
18 to 22	.25	6 to 9	
22 to 19	.19	6 to 8	
19 to 21	.36	7.8 to 8.5	
21 to 20	.20	7 to 9.5	
20 to 40	5.97	6½ to 10.8	
40 to 39	.29	5½ to 7½	Stake No. 39 is 1½ miles northeast of northern extremity of Loggerhead Island.
39 to 25	.44	6½ to 11.3	
25 to 36	1.89	8.4 to 13.4	
36 to 35	1.62	8.9 to 16.4	
35 to 34	.60	10.7 to 14.2	
34 to 33	.43	15.2 to 20.2	
33 to 32	.98	15.2 to 21.2	
32 to 31	.35	17.7 to 18.2	
31 to 30	1.17	11.4 to 16.4	
30 to 29	1.19	9.4 to 18.4	
29 to 28	1.29	14.4 to 21.4	
28 to 26	1.43	14.4 to 20.4	
26 to 27	.87	10.4 to 20.4	
27 to Punta Rosa.	1.48	10.4 to 20.4	From Boca Grande to Punta Rosa is 29.14 miles.

From Boca Captiva to Punta Rosa.—Boca Captiva is never entered by vessels sailing from Cedar Keys or other Gulf ports to Punta Rosa. In good weather they coast along Captiva and Sanibel islands, as before remarked, and turn the eastern extremity of Sanibel. In stormy weather it is hazardous to attempt to enter Boca Captiva from the Gulf on account of two long sand-spits, covered by shallow water, which make out from the south end of La Costa Island and the north end of Captiva Island, the former in a southwest direction for 1¼ miles and the latter in a west-northwest direction for about 1 mile. The channel pursued by vessels entering or leaving follows the edge of the La Costa spit more nearly than the edge of the other. Within the pass itself, between its head and outlet, the water varies from 17 to 29 feet in depth at mean low tide.

Between the outlet and the bar, a distance of 1 1/16 miles, the depth decreases, and is 12 feet on the bar. Thence it increases to 3 fathoms, at the distance of 1½ miles west of the north extremity of Captiva Island. Between the head of the pass and sailing-stake No. 21 (on the Boca Grande-Punta Rosa route) the depths of water vary from 6½ to 19 feet at mean low tide. A vessel drawing 6 feet can, therefore, readily enter Boca Captiva in moderate weather, and proceed by the harbor route to Punta Rosa. This pass, however, is only used by fishing schooners, not exceeding 5 feet draught, which touch at the fishing station on the northeast coast of Captiva Island. The accompanying tracing shows the track of vessels entering.

From Boca Ciega to Punta Rosa.—The figure of Boca Ciega has recently undergone a change, so that it is no longer a "blind pass," but the opening from the Gulf into the harbor is plainly visible as you sail past it in coasting along the Captiva and Sanibel islands; formerly the southern extremity of the former island projected in a southeasterly direction past the northwestern extremity of the latter, the two islands being separated by a water passage varying in width from 500 to 1,200 feet. From the entrance, the pass bore northwest by north for ¼ of a mile, and thence north-north-

east for 1¾ miles to its junction with Charlotte Harbor. But now the sea has made a breach, 400 feet wide, across Captiva Island, and has silted up the southern branch of the old pass, thus uniting the severed part of Captiva with Sanibel Island.

The present approach of Boca Ciega from the Gulf lies between two sand-spits, making out, the one from the northwest extremity of Sanibel Island, and the other from the southwest extremity of Captiva Island. The former laps past the latter about 600 feet in a west-southwest direction, and the two are not more than 300 feet apart at the narrowest part of the channel. Just before entering this outer pass, and abreast of the extremity of the south spit, there is a depth of 2½ fathoms. Thence to the mouth of the inner pass the depths vary from 6 to 16 feet, and thence to the head of the pass, in the general direction north-northeast, from 6 to 13 feet. Here the channel lies close to the north extremity of Sanibel, and proceeds thence along the northeast shore of that island for ¾ of a mile in the direction of the north extremity of Loggerhead Island, abruptly terminating against a long and wide sand-bar, which lies between the head of Boca Ciega and the Boca Grande-Punta Rosa Channel. Across this bar no passage could be found in any direction deeper than 2½ feet at mean low-water, though at high tide vessels of 3 to 3½ feet draught might cross it and make connection with the route to Punta Rosa. North of Boca Ciega and east of Captiva Island lie three islands, the largest of which is called Buck Island. Between these islands and Captiva is a strait varying from 90 feet to ⅝ mile in width. This was carefully sounded, and a channel was traced to a point about one mile northward of Buck Island, and close to the Captiva shore. The depths in this channel vary from 3.4 to 8.7 feet at mean low-water, and from its northern extremity a vessel sailing eastward can find entrance into the Boca Grande-Punta Rosa Channel, upon depths varying from 3.2 to 5.7 feet.

Through Boca Ciega, therefore, no vessels of greater draught than 3 feet can pass from the Gulf into Charlotte Harbor, except at high tide and by tortuous channels difficult to be followed. Indeed, it is rarely ever used, and then only by small sloops and sail-boats. It cannot be entered in stormy weather, and merits no expenditure whatever.

From the mouth of Caloosahatchee River to Peas Creek.—The passage of water separating Pine Island from the mainland on the east is called Metlochat Sound. Its shores are fringed with numerous islands, the largest of which lies closely against Pine Island, about midway between its northern and southern extremities, and measures 4½ by 2½ miles in extent. The width of the sound, east and northeast of this island, is contracted to about 1¼ miles, and here also, for a distance of 7 miles, the sound is obstructed by numerous islands and oyster bars. The upper and lower sound are much less obstructed by islands and afford deeper water than the middle part.

A channel, having ample depth at mean low-water for vessels of 6 or 7 feet draught, may be entered about ¼ mile southward of Punta Rosa, thence it runs west-northwest ½ north between Fisherman's Key and the southeast extremity of Pine Island, and traverses the lower sound, everywhere within ¾ mile of the eastern shore of the island.

The continuation of this channel through the middle sound is extremely tortuous, and unnavigable at mean low-water by vessels of more than 2 feet draught. Indeed, the Punta Rosa Hickory Bluff mail boat, a small sloop drawing 1 foot of water, the only vessel regularly navigating this part of the sound, sometimes finds difficulty, at low-water, in avoiding the oyster and sand bars. Ample depth for vessels of 6 feet draught is found in the upper sound, the channel for the most part lying midway between Pine Island and the mainland.

Schooners of 3 feet draught have sailed through Metlochat Sound on several occasions, but only with favorable winds and at high tides. It is only navigated by the sail-boats of a few families living on its eastern shore, who procure their supplies from Punta Rosa and Fort Myers. No expenditure for dredging any of its channels would be justified by the present trade.

An extensive sand-bar lies off the mouth of the Caloosahatchee River. Across this bar, in the direction from Sword Point (called also Punta Blanco) to Fisherman's Key, not more than 1 foot of depth exists at mean low tide. Vessels of greater draught than this, when sailing from the mouth of the Caloosahatchee to Hickory Bluff, usually pursue the Punta Rosa-Boca Grande route to stake No. 15, northeast of Boca Captiva. From this point they follow a channel, affording 6 feet of water, in the direction north ¼ east, passing between Patricio and Bird islands, until directly east of the northeast extremity of the former island, thence a course northeast by north ½ north gives a sufficient depth of water across the great sand-bar lying northwest of Pine Island, and brings the vessel within sight of the Cape Hayes stake.

From Gasparilla Pass to Hickory Bluff.—Through Gasparilla Pass schooners of 4 feet draught can find entrance into the northwest angle of Charlotte Harbor from the Gulf of Mexico. A sand-bar projecting in all directions from the north extremity of Gasparilla Island gives shape to the channel, which approaches the pass from the southwest, and on entering hugs its north shore. Thence its course, conforming to that of the sand-bar, veers to the southeast until when a vessel is due east of the head

of Gasparilla Island it is distant from it about 1¼ miles. From this point southeastward the channel lies about midway between Gasparilla Island and the assemblage of islands situated east of it. Pursuing this channel to a point abreast of the eastern extremity of Gasparilla Island, a vessel may thence coast along the island to Boca Grande, or direct her course to Cape Hayes.

Outside of Gasparilla Pass ¼ mile the water is 15 feet deep, and thence deepens to 30 feet in the pass. A mile further, following the channel above described, the water shoals to 5 feet, and thence to Boca Grande, or to Cape Hayes, a vessel of 4 feet draught will find a sufficient depth everywhere.

Gasparilla Pass is seldom entered except by vessels engaged in mullet-fishing, in the northwest part of the harbor, and never by vessels sailing from a Gulf port to Hickory Bluff. No appropriation should be made for the improvement of this pass or its connecting channels.

It is proper to add that Gasparilla Pass and the inside channel thence to Boca Grande, as also the central part of Metlochat Sound, were not sounded by us for lack of time, the appropriation forbidding a continuance of the work. The information given is derived from the masters of vessels long acquainted with these channels, whose independent statements agree with each other, and are doubtless correct.

The population of the islands and eastern shore of Charlotte Harbor is scanty in the extreme. Not more than twelve persons live on the islands, and a few families live on the shore between Punta Gorda and the mouth of Caloosahatchee River. The sole lucrative industries at present carried on are cattle raising and the harbor fisheries, the latter being almost exclusively in the hands of Cubans. Orange growing is increasing in importance, though the groves are yet too young for a great production. The cattle of this region are shipped exclusively to Cuba, either from Hickory Bluff or from Punta Rosa. The vessels navigating the harbor are accommodated to its channels, and are of sufficient capacity for the present business, and for any increase of business that may be reasonably anticipated. No improvement of harbor or passes, therefore, is now required.

Much credit is due to Capt. W. D. Collier, of Fort Myers, our pilot, whose knowledge of the harbor and its channels proved to be minute and exact. Thanks are also due to the rodmen, A. T. Smith, W. E. Dootch, and A. K. Meigs, who labored efficiently throughout the examination.

Very respectfully, your obedient servant,

J. L. MEIGS,
Assistant Engineer.

Capt. A. N. DAMRELL,
Corps of Engineers, U. S. A.

K 18.

EXAMINATION OF WITHLACOOCHEE RIVER, FLORIDA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., March 6, 1880.

SIR: By act of Congress approved March 3, 1879, an examination of the Withlacoochee River, Florida, was authorized, and was assigned to me by letter dated April 25, 1879.

This examination was made by Mr. J. L. Meigs as assistant engineer, upon whose report I have the honor to submit the following:

The examination was commenced at Hayes's Ferry, the highest point to which any improvement is at present considered expedient. The improvement from this point to the mouth of the river would relieve the present difficulty of getting the produce of Marion, Sumter, and Hernando counties to a market, and supplying the inhabitants with merchandise and provisions at a reasonable expense.

When the surveying party arrived at Hayes's Ferry, the river was about 6 feet above its lowest stage and the examination had to be carried on under this disadvantage; sufficient data, however, were obtained upon which to base an estimate for its improvement.

During high-water vessels drawing 4 feet can ascend the river, but as this season is usually short the improvement desired is the removal

of snags, overhanging trees, and loose rocks, and cutting through some of the worst shoals and a bar at the mouth, so as to enable boats drawing 2 feet of water to navigate the river during about one-half of the year.

The cost of this improvement is estimated at $23,874.04, and should it be deemed expedient to make the improvement I would recommend an appropriation of $20,000. It is expected that should this improvement be authorized the country along this river would be rapidly settled up, and that in a few years further improvements may become necessary.

No reliable statistics could be obtained as to the amount of commerce that would be immediately benefited by the improvement.

The report of Mr. J. L. Meigs is herewith forwarded for more detailed information, and a tracing of the map of examination of the Withlacoochee River will be forwarded as soon as made.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. J. L. MEIGS, ASSISTANT ENGINEER.

MOBILE, ALA., *January* 25, 1880.

SIR: In accordance with your letter of instructions of August 15, 1879, an examination of the Withlacoochee River, Florida, was made. The following report of the work is respectfully submitted:

The examining party, consisting of an assistant engineer, 3 rodmen, a pilot, and a laborer, were assembled at Clear Water Harbor on September 7, 1879, with the design of proceeding overland 76 miles to Hayes's Ferry, on the Withlacoochee River, where a flat-boat should be built and the descent of the river be there commenced. Ordinarily the rainy season of that region begins about the middle of June and terminates early in September. The rainfall during each of the years 1878 and 1879, however, proved to be unusually great and protracted. The party were unable to leave Clear Water Harbor before September 16, 1879, owing to heavy rain storms and overflowing streams, and the march thence around the head of Tampa Bay and across Hillsboro and Hernando counties was slow and tedious, ponds and submerged flat-lands being constantly encountered.

On September 23, they arrived at W. W. Mallard's Mill (then the only one on the Withlacoochee River), situated in township 21 south, range 20 east, near the west line of section 13 and about 4 miles by water below Hayes's Ferry. This ferry was selected as the initial point of the examination in accordance with the very general conviction of the best informed citizens, that to render the river navigable from its mouth to this point would not only greatly relieve the present difficulty experienced by the people of Marion, Sumter, and Hernando counties in procuring necessary supplies of goods and groceries, but that it would be inexpedient at present to expend money on the river above Hayes's Ferry. A bill for the improvement of the river, introduced at the last session of the Florida legislature, proposed that the work should be commenced at Mallard's Mill. It seemed proper, therefore, to begin the examination at Hayes's Ferry, and this was done on September 26, on the completion of the necessary boats.

Unfortunately the examination was necessarily made at a stage of water 6 feet above the ordinary summer stage. This great disadvantage was remedied as far as possible by employing for different sections of the river the services of experienced pilots, who had frequently descended the river on barges and rafts and in skiffs, and by obtaining information from every available source in regard to its obstructions.

By these means and by constant soundings the sites of shoals, whether of sand or rock, were ascertained. All snags and accumulations of logs and the overhanging trees and limbs were carefully noted, and, where the river banks were not submerged, observations of their materials were made. These necessary data for an approximate estimate of the cost of rendering the river navigable, so far as to relieve the present wants of the population, are given below in tabular form, as affording the easiest and readiest mode of examining the facts.

Withlacoochee River measurements and observations.

Division of river.	Subdivision of river.	Distances measured on map.	Width.	Depth at ordinary low-water.	Banks to be cleared of overhanging trees and timber.	Snags to be removed.	Remarks.
		Miles.	*Feet.*	*Feet.*	*L. feet.*		
I.—From south line of section 24, township 21 south, range 20 east, to south line of township 20 south, range 21 east.	Deep-water basin	1.53	90 to 150	5.5 to 6°	200	0	Hayes' Ferry, near south line of section 24, township 21 south, range 20 east. Banks of river submerged; soil of banks a sandy loam, with outcroppings of limestone.
	Three-Bridge Shoal	0.12	25 to 80	1.5 to 6.5	1,200	0	So called because bridge was built here by General Jesup, during the Seminole war, across the three narrow channels into which the river is divided by two islands. The river-bed here is a wooded lagoon traversed by these narrow channels into which the river is divided by two islands, of which the western affords the deepest water.
	Deep-water basin	0.15	70 to 170	3.5 to 5.5	1,560	0	
	Lake through which river flows	1.25	300 to 1,000	5.8 to 6	0	0	
	Deep-water basin	1.10	90 to 225	6 to 12	1,000	0	Basin ends about 500 feet below Mallard's Mill.
	Deep-water basin	0.16	25 to 85	3 to 6°	1,710	0	
	Lake	0.85	110 to 600	3 to 6.5°	0	0	
	Basin	0.15	40 to 90	3 to 6.5°	1,584	16	This basin ends at the head of Graham's Shoals.
	Graham's Shoals	0.06	25 to 40	1 to 3.5	600	10	River here runs through cypress brake, lower end of shoal, near east line of township 21 south, range 20 east.
	Graham's Shoals	0.08	60 to 200	1 to 4.0	0	0	
II.—Between south and north lines of township 20 south, range 21 east.	Lake	0.28	150 to 900	6 to 6.5°	0	0	
	Lake	0.31	120 to 600	6 to 6.5°	0	0	
	River basin	0.31	60 to 90	4.5 to 6.5°	1,180	0	
	Woodard's Bar	0.12	25 to 70	2 to 6.5°	264	0	
	River basin	0.07	50 to 80	2.6 to 6.5°	0	0	Basin terminates at head of Carter's Lake.

	Carter's Lake	1.42	125 to 1,000	3.6 to 6.5	0	0	This lake terminates about 600 feet north of north line of section 30, township 20 south, range 21 east.
	River basin	0.29	70 to 200	2 to 5	800	0	
	Bonnet Lake	1.12	150 to 2,600	4 to 6.5°	....	....	
	Bonnet Lake	0.88	100 to 700	4 to 5.5	....	....	Bonnet Lake terminates near the east line of section 17, township 20 south, range 21 east. The narrow lake widths are really widths of channels between the islands in the lake.
	Jumper's Lake, from east line of section 17 to north line of section 16.	1.06	25 to 70	3 to 6	1,500	50	These widths are widths of channels between islands.
	Jumper's Lake, between south and east lines of section 9.	0.50	65 to 150	1.5 to 4	....	....	
	Jumper's Lake, between east line of section 9 and point 500 feet south of northwest corner of section 11.	1.98	150 to 1,400	1 to 5	....	1	
	Jumper's Lake, from point last named to north line of section 2, township 20 south, range 21 east. Shoal water.	1.25	35 to 150	1 to 2	600	0	Better water attainable upon a more thorough sounding of the lake.
	River basin	0.25	80 to 90	1.5 to 6.5	400	0	Within this basin a rock shoal, 5 feet wide, crosses river diagonally; depth of water on it at ordinary low stage 2 feet.
III.—Between south and north lines of township 19 south, range 21 east.	River basin, two chutes of river running through heavily wooded lagoon.	0.50	35 to 50	3 to 7.5	5,000	....	The northeast chute affords the better water.
	Lake, from west line of section 36, township 19 south, range 21 east, to mouth of Panasofkee River.	1.02	200 to 400	3 to 5	0	0	
	Lake, from mouth of Panasofkee River to north line of section 26.	1.50	300 to 500	1.8 to 4.8	0	0	
	Lake, from last-mentioned line to north line of section 23.	1.38	300 to 500	3.3 to 5.5	0	0	Opposite Kilgour's landing two rocks in view, easily avoided.
	Lake, from last-named line to point 200 feet north of north line of section 16.	1.41	300 to 700	4 to 5.3	0	0	
	Lake, from point last named to north line of section 6, township 19 south, range 21 east.	3.12	250 to 300	3 to 5.8	0	0	
IV.—Between south and west lines of township 18 south, range 21 east.	Lake	1.09	200 to 500	5 to 7.5°	0	0	
V.—Between east and north lines of township 18 south, range 20 east.	Lake, from east line of section 36, township 18 south, range 20 east, to foot of lake near west line of section 25.	1.45	110 to 200	3.8 to 7.5	0	0	
	River basin, between west line of section 25 and north line of section 23.	1.78	60 to 250	3.5 to 7.5°	200	1	
	River basin, between north line of section 23 and north line of section 10, township 18 south, range 20 south.	4.30	90 to 300	3 to 7.5	....	1	
	Lake, between north line of sections 10 and 4, township 18 south, range 20 east.	1.63	200 to 500	2 to 7	600	1	The river on this subdivision follows numerous channels between heavily wooded islands.

Withlacoochee River measurements and observations—Continued.

Division of river.	Subdivision of river.	Distances measured on map.	Width.	Depth at ordinary low-water.	Banks to be cleared of overhanging trees and timber.	Snags to be removed.	Remarks.
		Miles.	*Feet.*	*Feet.*	*L. feet.*		
VI.—Between south and west lines of township 17 south, range 20 east.	River basin, between south line of section 33, township 17 south, range 20 east, and head of Morrison's Shoal.	0.30	40 to 100	2.5 to 6.5°	550	....	
	Morrison's Shoal, partly river basin and partly lake..	0.33	100 to 2000	2 to 4.8	....	....	This is a sand shoal or bar and is a great obstruction to navigation at extreme low-water.
	Partly lake and partly river basin, from foot of Morrison's Shoal to west line of section 19, township 17 south, range 20 east.	3.00	30 to 800	4 to 7	2,250	18	River channel narrow and traversing lake and heavily wooded lagoon.
VII.—Between east line of township 17 south, range 19 east, and Harrison's Ferry, ½ mile east of west line of section 8, same township.	River basin, from east line of section 24, township 17 south, range 19 east, and head of Horris Bridge Shoal.	1.75	30 to 100	2 to 2.5°	600	5	River here occupies a single channel.
	Rock Shoal, 600 feet long, and terminates 900 feet above Horris Bridge.	0.11	80	1 to 6	....	....	River bed covered with detached rocks of soft limestone and not of great size. This is not properly a shoal, but a part of river channel not much obstructed by loose rock at low-water.
	River basin	0.13	80	2 to 4	0	0	
	Rock shoal, from point 100 feet above north line of section 23 to point 400 feet below that line.	0.09	70 to 80	1 to 6	0	0	River bed covered with detached rocks, between which are numerous narrow and crooked channels.
	River basin, from point last named to Harrison's Ferry (old Camp Izard), ½ mile east of west line of section 8, township 17 south, range 19 east.	3.00	60 to 100	3 to 7°	3,000	0	
VIII.—Between Harrison's Ferry and mouth of Blue Spring Creek, near west line of section 36, township 16 south, range 18 east, a distance of 3.36 miles.*	River basin, rock bottom	0.26	70 to 90	2 to 7°	0	0	Hence to the river's mouth the distance across each shallow and shoal (in the direction of the current) was estimated, but not that across each basin of deeper water.
	Shoal, bottom rocky and sandy	0.08	75 to 150	1 to 6	....	1	
	Basin of deep water	......	100	7	200	1	
	Basin	0.08	75 to 90	2 to 7	....	....	
	Basin of deeper water	......	80 to 90	4 to 6	400	....	
	Basin	0.06	80	4.5 to 6	0	0	
	Basin of deeper water	......	80 to 90	5 to 5.5	500	0	
	Basin	0.06	85	4.5 to 5	600	0	
	Basin of deeper water, sandy bottom	......	60 to 80	5	600	0	
	Shallow	0.04	90	4 to 4.5	....	....	

Basin of deeper water	......		90	5	....	....
Shallow	0.04		75	4 to 4.5	600	0
Basin of deeper water	......		75	5	....	....
Shoal	0.05		80	1 to 3	200	0
Basin of deeper water, sandy bottom	......		90	3 to 5	....	....
Shallow	0.04		90	3 to 3.5	....	....
Basin of deeper water	......		90	4 to 8°	....	....
Shallow	0.05	85 to	90	2 to 3	....	....
Basin of deeper water	......		80	3½ to 5	200	0
Shoal	0.03		90	1 to 3	....	....
Basin of deeper water	......	70 to	80	7.5 to 8°	1,400	0
Shallow, rocky bottom	0.05		80	2.5 to 4.5	....	....
Basin of deeper water	......		80	4.5 to 6	....	....
Shoal, rocky bottom	0.30	80 to	100	1 to 6	....	....
Basin of deeper water	......		100	6	....	....
Shallow	0.04		90	2 to 5	....	....
Basin of deeper water	......		90	5 to 6	....	....
Shallow	0.03	80 to	90	2 to 5	....	....
Basin of deeper water	......	80 to	90	6 to 8	500	1
Shoal	0.44	85 to	90	0.5 to 5	....	....
Basin of deeper water	......		85	5 to 8	....	....
Shoal	0.17	80 to	90	0.5 to 6	....	....
Basin of deeper water	......		90	5 to 7	400	....
Shallow	0.04		80	2 to 4.5	....	1
Basin of deeper water	......		90	4 to 5	....	....
Shallow	0.03		90	3 to 4	....	....
Basin of deeper water	......		65	5 to 6	1,100	....
Shallow	0.03		90	2.5 to 4	....	....
Basin of deeper water	......	70 to	90	4 to 6	600	....
Shallow	0.09	70 to	90	2 to 5	600	3
Basin of deeper water	......		70	6	600	....
Shoal	0.03	70 to	80	0.5 to 4	800	....
Basin of deeper water	......	70 to	100	3 to 6	....	....
Shallow	0.01		70	2.5	....	....
Basin of deeper water	......	70 to	75	4 to 8°	1,000	....
Shallow	0.04		75	3 to 4	....	3
Basin of deeper water	......		65	8	400	....
Shoal	0.07		75	1 to 4	....	....
Shoal	0.06		80	0.5 to 4	....	....
Basin of deeper water	......	65 to	80	3 to 8°	800	....
Shoal	0.07		80	1 to 3	....	....
Basin of deeper water	......		50	6	400	....
Shallow	0.04		50	4	600	....
Basin of deeper water	......		50	5 to 6	....	....
Shallow	0.07		90	2 to 5	....	....
Shoal	0.61		90	1 to 4	....	....
Basin of deeper water	......		90	5 to 6	....	....
(Sum of distances across basin of deep water on this division, 0.61 mile.)						

Rock bottom for 1,300 feet, thence sandy. (remark beside the Shoal, 0.44 row)

*The sum of the distances across the shallows and shoals of this division is 2.55 miles, and the sum of the distances across the deeper water separating the shoals is 0.81 miles.

Withlacoochee River measurements and observations—Continued.

Division of river.	Subdivision of river.	Distances measured on map.	Width.	Depth at ordinary low-water.	Banks to be cleared of overhanging trees and timber.	Snags to be removed.	Remarks.
		Miles.	*Feet.*	*Feet.*	*L. feet.*		
IX.—From Blue Spring Creek to Hatcher's Ferry, near middle of section 31, township 16 south, range 18 east, a distance of 5.1 miles, of which the sum of the distance across shoals and shallows is 1.4 miles, and the length of the deep basins amounts to 3.7 miles.	River basin	......	100 to 160	8	....	4	
	Shallow	0.03	100	2 to 3	....	....	
	Basin of deeper water	......	100	5 to 8	....	....	
	Shallow	0.06	100	2 to 4	....	....	
	Basin of deeper water	......	100	8	....	....	
	Shallow	0.17	100	2 to 5	....	....	
	Basin of deeper water	......	100	8	....	....	
	Shallow	0.09	100	2 to 4	....	....	
	Basin of deeper water	......	110	6 to 8	....	....	
	Shallow	0.04	110	3 to 5	....	....	
	Basin of deeper water	......	110	8	....	....	
	Shallow	0.10	100	2 to 6	....	....	
	Basin of deep water	......	110	8	....	....	
	Shallow	0.09	105	3 to 4	....	....	
	Basin of deeper water	......	105	5 to 6	....	....	
	Shallow	0.07	120	2 to 4	....	....	
	Basin of deeper water	......	90 to 110	5 to 8	200	....	
	Shallow	0.07	100	3 to 4	....	....	
	Basin of deeper water	......	100	8	....	....	
	Shallow	0.07	110	2 to 4	....	1	
	Basin of deeper water	......	110	8	....	....	
	Shallow	0.10	110 to 120	2 to 4	....	....	
	Basin of deeper water	......	120	5	....	....	
	Shallow	0.08	110	2 to 4.5	....	....	Bottom sandy and rocky.
	Basin of deeper water	......	110	6 to 8	160	....	
	Shallow	0.08	110	2 to 4	150	....	
	Basin of deeper water	......	80 to 90	8	1,600	....	
	Shallow	0.04	100	3 to 4	....	....	
	Basin of deeper water	......	100	5 to 6	1,100	1	
	Shallow	0.01	100	3 to 4	....	....	
	Basin of deeper water	......	100	8	....	....	
	Shoal	0.05	100	1 to 4	....	....	
	Basin of deeper water	......	65 to 110	5 to 8	2,100	7	
	Shallow	0.04	80	3 to 4	400	2	
	Basin of deeper water	......	80 to 85	5 to 8	....	....	

	Shallow	0.05	120	3 to 5			
	Basin of deeper water		85 to 125	5 to 8°	600		
	Shallow	0.03	100	2 to 4			
	Basin of deeper water		100	5 to 8			
	Shallow	0.03	100 to 110	3 to 4.5			
	Basin of deeper water		100	8			
	Shallow	0.01	100	3			
	Basin of deeper water		100	8		1	
	Shallow	0.04	100	3.5 to 4			
	Basin of deeper water		110	5 to 8			
	Shallow	0.02	105	2.5 to 3			
	Basin of deeper water		105	8			
	Shoal, bottom of loose rocks	0.09	100 to 120	1 to 5		1	Opposite Dr. Hodge's field.
	Basin of deeper water		100 to 110	8°			Hatcher's Ferry.
	(Sum of lengths of basins of deep water on Division IX is 3.7 miles.)						
X.—From Hatcher's Ferry to west line of section 7, township 17 south, range 16 east, distance of 14.96 miles.	River basin		100 to 110	8°	100		
	Shallow	0.05	100	2 to 5			
	Basin of deeper water		100	8	200		
	Shoal	0.05	100	1 to 3			Lowest shoal on river. Channel hence to mouth everywhere deep.
	River basin, from shoal last named to Fort Clinch, on section 4, township 17 south, range 17 south.		90 to 130 90 to 150	6 to 8° 8°	900		
	River basin, from Fort Clinch to Blind Horse Island		100 to 160	8°	400	3	The narrow width is that of North Chute of Blind Horse Island.
	River basin, from Blind Horse Island to Venner's Creek, a narrow outlet of the Withlacoochee, diverging to southwest and emptying into Gulf of Mexico.		60 to 130	8°			
	River basin, from Venner's Creek to northeast extremity of Chambers's Island.		90 to 250	8°		1	
XI.—From west line of section 7, township 17 south, range 16 east, to a point 200 feet on side of North Pass.		0.33	150 to 250	3 to 6.5			From Hayes's Ferry to North Pass the length of the river is 66.68 miles, by measurement on the plats of the United States land surveys.
XII.—From west line of section 7, township 17 south, range 16 east, to South Pass.		0.63	80 to 250	2 to 6.5			These, however, do not show the bends of the river correctly. The distance must be quite 100 miles.

The Withlacoochee River from Hayes's Ferry to the western line of section 19, township 17 south, range 20 east, below Morrisson's Shoals, traverses a series of open lakes and wooded lagoons, generally shallow and of varying widths. The lakes are interspersed with floating masses of wild lettuce, bonnets and careless weeds, and with numerous islands covered with willows and aquatic plants. The wooded lagoons are heavily timbered, and traversed by one or more narrow and crooked channels, which, however, afford 2 to 4 feet of water at the ordinary low-water stage, though in many places not more than 30 feet in width. The current flowing in the lake channels is sluggish while that in the lagoon channels generally flows swiftly.

From the western line of section 19 (above mentioned) to the mouth, the river, for the most part, confines itself to a single channel, the width is more uniform, the current rapid, and the bed generally covered with loose rocks at the places of shoals and shallows. The channels between these rocks are narrow, crooked, and impassable at very low water. These places are miscalled shoals in many cases, since the depth of water between the rocks is as great as is elsewhere obtained. Here the river can be rendered navigable by breaking up and removing the soft limestone rocks, which are generally much less than a cubic yard in size.

Just above the mouth the river is divided by Chambers's Island into two branches, flowing northwest and southwest, respectively. The north branch affords quite as good water as the other, and has the better approach from the Gulf of Mexico. This approach is a narrow channel (from 1¼ to 3¼ feet deep at mean low-water), which crosses a shallow bar, composed chiefly of oyster beds and lying off the mouth of the river. For ¾ of a mile, this channel, which has an average width of 30 feet, should be dredged to a width of 50 feet, and a depth of 3 feet, at mean low-water.

The river has never been regularly navigated by vessels. A small steamer, drawing about 2 feet, has ascended it to Fort Clinch. Capt. D. M. Lay has made two trips, at ordinary low-water, from the mouth of the river to Panasofkee Outlet, on a barge carrying 18 tons, and drawing 18 inches of water. A small barge has also been taken up as far as Pemberton's Ferry; and Mr. W. W. Mallard has carried a barge loaded with lumber from his mill on section 13, township 21 south, range 20 east, to Panasofkee Outlet. Rafts of cedar logs, however, are frequently brought out of the river (even from the region about Fort Dade), and taken to the merchant mills at Cedar Keys. These require a depth of 2 feet of water everywhere in the channel, while rafts of palmetto logs (from the region immediately above the mouth of the river) require 3 feet in the river and across the bar. Except by barges, no attempt has been made to carry supplies of provisions and goods up the river. The people now, however, very earnestly desire the introduction of steam navigation. The influx of population from other States into the counties bordering on the river, and the extensive plantations of orange trees on the Panasofkee Lake and outlet, and on the Withlacoochee also, make an immediate improvement of the river navigation very necessary. The orange groves of Messrs. Young and Adams, and of Messrs. Conover and Lay, on the Panasofkee Outlet, will alone give employment to a river steamer during the fruit season.

The extent of the improvement now to be made should be decided by the needs of the population, and the ordinary stage of water in the river between the rainy seasons. Vessels drawing from 14 to 24 inches, such for example as navigate the Ocklawaha River and many tributaries of the Mississippi, will not only afford ample tonnage for the business of the Withlacoochee, but will be of as great draught as can regularly navigate it at the ordinary stage of the water. It is certain that on one occasion within the past thirty-five years the river bed in the vicinity of Mallard's Mill was perfectly dry (with the exception of deep pools of standing water) during a season of great drought; and at other dry seasons the stream has been so reduced in volume at the different shoals as to be unnavigable by vessels drawing 18 inches of water.

Old residents of the region bordering the river, and raftsmen engaged in carrying cedar logs down it, agree in opinion that no greater improvement need now be undertaken than to make the river navigable during the six or seven months following the rainy season for vessels not exceeding 2 feet in draught, and that this may be done by clearing its banks of overhanging trees and limbs, and by removing sunken logs, snags, and loose rocks from its bed.

It is not recommended to clear a *belt* of timber bordering on each of the river banks, but only to remove overhanging trees and limbs that would impede passing boats. The timber growing on the slopes and crests of the banks should be carefully preserved as a means of holding the sandy soil in place and preventing the sliding of the banks into the stream. Such slides of sandy river banks render the river shallow (as has been observed in the case of certain streams in Georgia), by widening its bed and filling the channel with sand. Rocks can readily be got out of the way by depositing them in near pools of deep water.

The deepening of the channel across sand shoals or bars will extend the period of navigation every year for a month or more. Many of the smaller sand-bars (of which 23 have been noted) will be deepened by the action of the stream alone, when the re-

moval of the loose rocks, sunken logs, and brush shall give free play to the current. The method of deepening such channels by dredging, or the more economical excavation with shovels and barrows, during a period of extreme low-water, should only be resorted to where there are good grounds for believing that the new channel will afterwards be kept clear and open by the action of the current above. Such places, it is believed, are Morrisson's Shoal and certain small islands in the upper river, the removal of which will give room for navigation.

In the case of other bars, low dams of closely driven piles may be built, so as to confine the running water to a single channel, which will thus be kept open. In the accompanying estimate, however, the cost of deepening bars is approximated by estimating the work in each case as excavation.

Approximate estimate of the cost of improving Withlacoochee River between Hayes's Ferry and its mouth.

Division of river.	Quantity and price.				Cost of work.
	Earth excavation.	Rock excavation.	Banks to be cleared of overhanging trees, &c.	Snags to be removed.	
	Cubic yards.	*Cubic yds.*	*Linear feet.*		
I	3 044 at 30 cents		7,854 at 1½ cents	26 at $10	$1,291 01
II	300 at 30 cents		4,244 at 1½ cents	51 at $10	663 66
III		89 at $1	5,000 at 1½ cents		164 00
IV*					
V			800 at 1½ cents	3 at $10	42 00
VI	6,519 at 30 cents		2,800 at 1½ cents	18 at $10	†2,177 70
VII		1,400 at $1	3,600 at 1½ cents	9 at $10	‡1,544 00
VIII	11,787 at 30 cents	3,578 at $1	12,500 at 1½ cents	13 at $10	7,430 60
IX	333 at 30 cents	500 at $1	6,300 at 1½ cents	17 at $10	864 40
X	667 at 30 cents		1,600 at 1½ cents	4 at $10	264 10
XI	2,778 at 30 cents				833 40
XII*					
Channel across bar	15,400 at 30 cents				4,620 00
Add for engineering and contingencies					3,979 17
Total					23,874 04

* No work recommended to be done on this division.
† This includes cost of excavating a channel (2 by 50 feet in section) across Morrisson's Shoal.
‡ This includes cost of removing loose rocks from river bed at Horn's Bridge Shoals.

Mention having been made of the fact that cedar rafts have been brought down the river from the vicinity of Fort Dade, it may be well to add that many persons regard the river as navigable for 15 miles above Pemberton's Ferry, and think that the improvement of the channel should extend to that point. They report that within 1½ miles above Hayes's Ferry there is a sand-bar 100 yards long, on which the water at its ordinary low stage is 1½ feet deep. Immediately above this is the foot of Cypress Island, from which point the eastern chute of the river is to be ascended. This chute is from 90 to 100 feet wide, and is much obstructed by logs. These removed, there would be from 3 to 4 feet of water in the shallow parts of the chute.

From the head of Cypress Island upward to Pemberton's Ferry the depth of water in the shallows is equally good, while 10 to 15 feet may be had at the other places. And for 15 miles above the ferry the depth of water is also good, 3 to 4 feet being obtainable at the low stage of the water. The width is everywhere from 90 to 100 feet. The growth of the country may, indeed, hereafter require the improvement of this part of the river.

Thanks are due to Capt. C. F. Adams for valuable memoranda in regard to the river, and for other information; also to Messrs. W. W. Mallard and L. L. Hodges.

Respectfully submitted.

J. L. MEIGS,
Assistant Engineer.

Capt. A. N. DAMRELL,
Corps of Engineers, U. S. A.

K 19.

EXAMINATION OF PEA RIVER, ALABAMA, FROM GENEVA TO ELBA.

OFFICE OF UNITED STATES ENGINEER,
Mobile, Ala., March 3, 1880.

SIR: By act of Congress approved March 3, 1879, an examination of the Pea River, Alabama, was authorized, and by letter dated May 12, 1879, was assigned to me, and was put in immediate charge of Mr. Hiram Haines, assistant engineer, whose report shows that from Elba, where the examination was commenced, to its mouth, a distance of about 60 miles, the river in its present condition is not navigable. In the upper portion of the river the chief obstructions are rock shoals, while the lower portion is filled with snags and logs to such an extent as to make its passage even with a small boat extremely difficult. To make this river navigable for light-draught boats during high-water season, from Elba to its mouth, an appropriation of $56,750 would be required, which estimate includes the construction of two locks and dams.

As, however, all the commerce of this river would probably pass over the Choctawhatchee River in its way to market, and would for a number of years be small in extent, I would recommend its improvement be delayed until that of the latter river is completed.

The report of Mr. Haines and a tracing of index map are herewith inclosed, to which I would respectfully refer.

Respectfully submitted.

A. N. DAMRELL,
Captain of Engineers, U. S. A.

THE CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. HIRAM HAINES, ASSISTANT ENGINEER.

MOBILE, ALA., *October* 18, 1879.

SIR: I have the honor to submit the following as the result of my examination of Pea River, Alabama, from Elba to its confluence with the Choctawhatchee River, made agreeably to your instructions of the 4th of August, 1879, at Geneva, Ala.

The river at Elba cuts through a heavy bed of soft, thinly laminated argillaceous rock, forming perpendicular banks, and a succession of shoals for 5 to 6 miles below the town.

At Churchill's Bridge, 7½ miles below Elba, this rock is replaced by beds of clay interstratified with thin layers of soft sandstone, which show, at intervals, just above the surface of the water along the margin of the stream. To this point the river is from 100 to 150 feet wide, comparatively straight, and the shoals form the chief obstructions to navigation. At 12 or 15 miles from Elba the banks become low and less resistive, and the stream more winding in its course. At 25 miles the white limestone develops itself in heavy beds, forming mural banks for 10 or 12 miles, and, by protecting the adjacent timber from being undermined, renders the river free from obstructions of this kind. Upon the disappearance of the limestone, the banks again become low, and the river enters a swamp. Its course becomes extremely tortuous; its volume often greatly diminished by outflows or cut-offs, and the bed so filled with snags and fallen trees as to render its passage extremely difficult. At Stevens's Ferry, 50 miles from Elba, the river emerges from the swamp, one of the principal cut-offs rejoins it, and the stream becomes broad, less winding, and free from obstructions from thence to its confluence with the Choctawhatchee.

The length of the river from Elba to the Choctawhatchee is about 60 miles, or about twice the distance in a straight line. The following is an estimate of the cost of improving this part of the river to render it navigable for barges and small steamboats

for six months in the year, its navigation for a longer period being considered impracticable:

For the construction of two dams and locks of crib work, 5 feet high, for overcoming falls and shoals between Elba and Churchill's Bridge, at $15,000	$30,000 00
For removing snags and fallen trees	9,250 00
For one snag-boat	7,000 00
For dredging and rectification of channel	7,500 00
For 300 linear feet of dike, at $5	1,500 00
For 500 linear feet of brush dam, at $3	1,500 00
	56,750 00

About nine thousand bales of cotton are made annually in Coffee County, of which about 500 are sold in Elba. Nearly the entire crop is hauled to Troy, an average distance of 35 miles, at present the most accessible market for this section of the State. This county also produces about 50,000 pounds of wool. The uplands, which are generally finely timbered with yellow pine, are admirably adapted to stock raising, and the river and creek bottoms to the cultivation of cotton, corn, tobacco, sugar-cane, and rice. They yield largely of the two latter crops, though the amount produced of either is commonly restricted to domestic wants.

As a considerable development of the country along the river would have to take place, and the production of the above commodities very greatly increase in order to induce steamboat navigation, I would consider any expenditure, at the present time, for locks and dams (which could only be required for this purpose) premature and inadvisable. I am, therefore, of the opinion that the work cited in the foregoing estimate, exclusive of the locks and dams, would provide amply for such transportation as will be required for many years to come.

An index map of the Choctawhatchee and Pea rivers, showing their relation to Pensacola (the nearest port of entry), accompanies this report. The field notes give in detail my observations in regard to the character of the river.

Very respectfully, your obedient servant,

HIRAM HAINES,
Assistant Engineer.

Maj. A. N. DAMRELL,
Captain, Corps of Engineers, U. S. A.

APPENDIX L.

INSPECTION OF THE IMPROVEMENT AT THE SOUTH PASS OF THE MISSISSIPPI RIVER.

REPORT OF CAPTAIN WILLIAM H. HEUER, CORPS OF ENGINEERS, INSPECTING OFFICER, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

NEW ORLEANS, LA., *July* 21, 1880.

GENERAL: I have the honor to transmit the annual report of the progress of work on the improvement of the South Pass of the Mississippi River.

The body of the report is made by Mr. C. Donovan, assistant engineer, who is the local engineer in charge of the surveys and examinations being made there.

An examination of the report and charts shows that at the end of the fiscal year there was through the jetties a channel 30 feet deep, having a least width of 40 feet, while the 26-foot channel has a least width of 200 feet. Near the head of the passes in the channel there is but one spot having a less depth than 26 feet. At this *point* the depth is 25.6 feet. One year ago the depth at the same place was 24 feet. In other words, there is now a ship channel from the Gulf of Mexico into the Mississippi River 200 feet wide and having a depth of 26 feet, except in one little spot just referred to.

A survey outside of the jetties was made, covering about 1¼ square miles of area, with a view to determine the amount of scour or fill that had occurred. The change since last report was so slight as to amount to practically nothing. The survey showed a mean *scour* of about .12 of a foot. The aggregate amount of deposit or fill in this area from 1876 to June 30, 1880, has averaged in vertical height 1.04 feet.

The very decided improvement in the depth of water through the jetties during the year is probably due to the immense concrete blocks and walls placed on the jetties, which confined the water within the jetties and thereby increased the scour. For details of these blocks, their size, subsidence, &c., see the detailed report. The report also contains details of all cribs and other work done by Mr. Eads during the fiscal year.

Respectfully submitted.

W. H. HEUER,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. C. DONOVAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., July 15, 1880.

SIR: In compliance with your verbal instructions I have the honor to present herein a report of the progress made in the improvement of South Pass of the Mississippi River, by Mr. James B. Eads, during the fiscal year ending June 30, 1880, and also the results of examinations and surveys made during the year.

HEAD OF PASSES.

With the exception of "Upper Dam," the works at this point remain in substantially the same condition as when last reported upon (June 30, 1879). The work during the year has been very slight, consisting in placing two tilted mattresses, each 60 feet long, 22 feet wide, and 1 foot thick, to close a break in the extension of east T-head dam, and twenty-five hours' dredging to increase the width of the 26-foot channel.

The above-mentioned work was done previous to July 25, 1879.

In the construction of mattresses 82¼ cords of willows were used.

From July 25 to December 27, 1879, the works here remained in good condition, only a slight sinking of the mattresses having occurred. About December 27, owing to the pressure on the "Upper Dam," caused by the rising of the river, this structure was undermined in two places and carried away. These breaks have gradually increased, until, on June 30, they were respectively 130 and 620 feet wide, having a depth of 18 feet of water through them.

The only portion of this dam which is in place and above average flood tide is 430 feet of the western end. The other portions not carried away are still in place, but their surfaces are from 5 to 12 feet below average flood tide. On Chart No. 4 the portions of this dam which have disappeared are indicated by a broken line.

The deterioration of this dam has not been detrimental to channel improvement, especially below it, as there has been a constant and, at times, a rapid deepening since it was completed, and especially during high river.

It is considered that this dam has served the purpose for which it was built, and that it will not be necessary to rebuild it.

DAM AT BAYOU GRANDE.

No work has been done on the dam across this outlet to South Pass during the year. The work still remains in fair condition, only a settling of the mattresses having occurred. The upper surface of the top mattress is now 2¼ feet below average flood tide. The bayou above the dam has become so filled with deposit that the average depth of water through it is about 4½ feet.

At high tide there is a sluggish current through the bayou, and its discharge is slight, being to some extent obstructed by flood-wood, which has collected above the dam.

AT THE MOUTH OF SOUTH PASS.

(a) East Jetty.

The work at the mouth of South Pass during the year has been chiefly confined to the building up of this structure, as it is the more important one, being subjected to the majority of the violent wind storms which visit this section.

The following is a classification of the work on this jetty:

1. Building and sinking of crib work.
2. Placing of concrete blocks.
3. Building parapet wall on concrete blocks.
4. Miscellaneous work.

1st. *Building and sinking of crib work.*—This work is for the purpose of strengthening and protecting the sea ends of the jetties, and in some cases it forms the foundation for concrete blocks. The cribs consist of piles laid in alternate horizontal courses, crossing each other at right angles. The piles in the floor courses are placed in contact with each other, and those of the upper courses are from 5 to 7 feet apart, thus forming compartments from 4 to 6 feet square. The piles are held together by drift bolts at every point of contact, and also by iron straps passing around the exterior piles of three or four courses.

In many of the cribs the floor is formed of 10 by 3 inch lumber, and the spaces between the piles are closed by chinking, or by inch planks nailed on the inside.

These cribs are built on ways, and when completed are launched and floated into position, and sunk by filling the compartments with stone. They vary somewhat in form, according to the position they are to occupy, and are placed so that the top of the crib will be at average flood tide. A slope is formed by omitting piles in the courses in one direction, and shortening those in courses at right angles, or by elevating one end of the piles so as to form the desired slope, the other end being in contact with the lower horizontal course.

Cribs are built of palmetto, pine, and cypress piles; those constructed of palmetto piles are from 40 to 70 feet long, and from 15 to 20 feet wide, their heights varying according to the depth of water at the point where they are to be placed. These are sunk near and about the extreme ends of the jetties, usually with their greatest dimension parallel to the axis of the jetty.

The other class, denominated *spur cribs*, are built of pine or cypress piles and plank, usually 25 feet long and 20 wide, with their greatest vertical dimension, with one exception, not exceeding 8 feet. They are placed in shoal water at intervals along either side of the jetties, with their length perpendicular to the axis of the jetty, and serve to strengthen the concrete wall, and break the swells which race along the sea side of

the concrete blocks with undermining effect; they will also serve as a foundation for concrete blocks, which it is proposed to place upon some of them in the future. During the year twenty-two cribs have been built and placed in position about the east jetty.

On Chart No. 5 is given a plan of the end of the jetties, showing the total number and position of cribs in place, and a cross-section of the east jetty near its end, or 11,773 feet from East Point, which will serve to show the construction of them.

The following table gives the dimensions, contents, character, &c., of each crib placed during the year, and their position with reference to either jetty. The number of each crib corresponding to that given in the table will be found on the plan above referred to:

Table giving dimensions, character, and location of cribs.

No. of crib.	Month when sunk.	Description.	Dimensions.	No. of feet palmetto.	No. of feet cypress.	No. of feet pine.	No. of feet plank.	Location.
	1879.		*Feet.*					
8	July	Spur	25 × 20 × 6			700		Station 112, sea side, East Jetty.
9	....do	...do	25 × 20 × 6			640		Station 110, sea side, East Jetty.
10	....do	...do	25 × 20 × 6			700		Station 108, sea side, East Jetty.
11	..do	...do	25 × 20 × 3.5			460		Station 114, sea side, East Jetty.
12	....do	...do	25 × 20 × 3.5			460		Station 112, sea side, West Jetty.
13	....do	...do	25 × 20 × 6			700		Station 114, sea side, West Jetty.
14	...do	...do	25 × 20 × 6			700		Station 113, river side, East Jetty.
15	..do	...do	25 × 20 × 5			620		Station 115 + 50, river side, East Jetty.
16	...do	...do	25 × 20 × 6			680		Station 111, river side, West Jetty.
17	....do	..do	25 × 20 × 5			520	80	Station 113, river side, West Jetty.
18	August	..do	25 × 20 × 5			276	360	Station 111, sea side, East Jetty.
19	...do	...do	25 × 20 × 5			225	380	Station 113, sea side, East Jetty.
20	....do	...do	25 × 20 × 5			225	380	Station 115, sea side, East Jetty.
21	...do	...do	25 × 20 × 5			225	380	Station 110, river side, West Jetty.
22	....do	...do	25 × 20 × 5			225	380	Station 111 + 80, river side, West Jetty.
25	...do	...do	25 × 20 × 8			456	260	Station 114 + 50, river side, East Jetty.
7	....do	Palmetto	72 × 16.5 × 16	5,597				Sea side, end West Jetty.
23	...do	...do	40 × 20 × 8	780		1,080		Under trestle, end West Jetty.
29	September	...do	40 × 20 × 6	600	440			Sea side, end East Jetty.
30	....do	...do	40 × 15 × 5	472	400			Do.
31	....do	...do	40 × 20 × 7	952	520			Do.
26	....do	Spur	20 × 20 × 8			800	580	Station 115, sea side, West Jetty.
32	October	...do	40 × 20 × 12		2,500			Station 116, sea side, East Jetty.
33	....do	Palmetto	30 × 15 × 15	1,210	450			Sea side, end East Jetty.
34	November	...do	40 × 15 × 15	1,170	450			Do.
35	....do	...do	30 × 17 × 19	1,980	450			Do.
	1880.							
36	February	...do	40 × 15 × 15	1,170	450			Do.
37	May	...do	49 × 14 × 6	1,164	637			Under trestle, end East Jetty.
38	June	...do	45 × 14 × 7	1,160	585			Do.
39	....do	...do	40 × 14 × 14	1,904	520			Do.
1	....do	...do	40 × 21 × 10	1,953				River side, end East Jetty.
	Totals			20,112	7,402	9,192	2,800	

In sinking these cribs 3,801 cubic yards stone have been used; in addition, 64 cubic yards macadam and 12 cubic yards gravel were placed in crib thirty-eight, and 30 cubic yards macadam and 18 cubic yards gravel in crib thirty-seven.

2d. Placing of concrete blocks.—The work preparatory to the placing of these blocks of artificial stone, that is, preparing the foundation, building the elevated railway for the transportation of the mixed concrete, &c., has been fully described in a previous report (see Annual or 12th Report, 1878–'79, page 6). November 15, preparations

were begun for the continuation of this work on the East Jetty upwards from Station 93 + 96, where it terminated July 1, 1879.

The elevated railway was continued from the same point to its present terminus (Station 65 + 15), a distance of 2,881 feet; 1,155 feet of this length was built by transferring all that portion of a similar railway on the West Jetty above △ cement; the remaining 1,726 feet is of new construction.

Up to July 1, 140 concrete blocks were placed above Station 93 + 96, which brings the present terminus of this work to Station 65 + 15 or 6,515 feet below East Point, the commencement of the east jetty. These blocks average about 20.1 feet in length, are 3 feet thick, and vary in width from 4 to 4¼ feet, and are separated by a distance of about $\frac{6}{10}$ of a foot.

On July 1, 1879, the sea end of the concrete blocks was at Station 116 + 33, terminating with block number ninety-one, which had been undermined and broken. This block has been rebuilt, and the work extended seaward to Station 117 + 73, a distance of 140 feet, by the addition of three blocks, numbered respectively ninety-two, ninety-three and ninety-four.

These blocks rest upon crib foundations, and are of the following dimensions:

No. 92, 51.6 feet long, 10.6 feet wide, and 3.6 feet thick.

No. 93, 46.3 feet long, 10.8 feet wide, and 4.0 feet thick.

No. 94, 41.9 feet long, 12.0 feet wide, and 4.8 feet thick.

The average weight of these blocks is about 158 tons, the heaviest (No. 94) being 180 tons.

These blocks were built with their ends in contact, thus making one continuous block.

The present termini of the concrete blocks, that is, Stations 65 + 15 and 117 + 73, are fixed as points beyond which it will not be necessary to carry this work, at least for the present.

Number of linear feet of concrete blocks built	2,951
Number of cubic yards of concrete used	1,471
Number of cubic yards of gravel in foundation	721

The following tables are presented, as they give in detail information regarding the settling of the concrete blocks:

Tables showing elevation of concrete blocks, at various dates, above the plane of average flood-tide, and the total subsidence of each block from the date of the first observation.

EAST JETTY—BELOW STATION 101 + 15.

No. of block.	Date when laid.	Elevation, February 4, 1879.	Elevation, February 11, 1879.	Elevation, March 5, 1879.	Elevation, March 31, 1879.	Elevation, April 28, 1879.	Elevation, July 1, 1879.	Elevation, September 9, 1879.	Elevation, October 17, 1879.	Elevation, November 26, 1879.	Elevation, December 27, 1879.	Elevation January 28, 1880.	Elevation, February 27, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
1	Jan. 10	1.64	1.95	....	0.83	..	....	2.52	2.45	2.42	2.36	...	..	0.16	Station 101 + 15.
2	10	0.75	0.87	....	0.84	....	....	2.4[illegible]	2.38	2.34	2.29	..	....	0.17	Nos. 1 to 6 inclusive raised by
3	9	1.91	0.87	....	0.81	....	....	2.41	2.34	2.31	2.24	....	....	0.17	concrete during April, 1879.
4	9	....	0.86	....	0.65	....	....	2.4[illegible]	2.30	2.32	2.26	..	....	0.17	
5	8	....	0.74	....	0.77	....	....	2.6[illegible]	2.57	2.56	2.36	....	....	0.30	
6	7	.	0.82	....	0.83	....	....	2.81	2.71	2.63	2.52	....	...	0.29	Station 102.
7	4	....	1.03	....	....	..	....	....	...	....	....	....	...	0.64	Under mixer.
	1878.														
8	Dec. 28	1.65	1.61	1.53	2.48	2.52	2.47	2.14	2.07	2.01	1.96	1.91	1.84	0.64	Nos. 8 to 13 inclusive raised by
9	29	1.64	1.61	1,55	2.66	2.68	2.62	2.3[illegible]	2.31	2.27	2.24	2.11	2.08	0.58	concrete between March 5
10	31	1.42	1.43	1.39	2.73	2.71	2.76	2.51	2.46	2.42	2.39	2.21	2.18	0.57	and March 31, 1879.
	1879.														
11	Jan. 1	1.28	1.29	1.24	2.74	2.77	2.70	2.4[illegible]	2.40	2.36	2.33	2.20	2.17	0.57	Station 103.
12	2	1.41	1.40	1.35	2.78	2.85	2.78	2.5[illegible]	2.50	2.45	2.42	2.24	2.22	0.56	
13	3	1.18	1.14	1.13	2.73	2.85	2.73	2.5[illegible]	2.34	2.28	2.27	2.19	2.17	0.63	
14	10	1.34	1.23	2.74	2.66	2.64	2.54	2.31	2.27	2.21	2.20	2.14	2.11	0.63	Nos. 14 to 19 inclusive raised
15	11	1.31	1.24	2.68	2.57	2.59	2.49	2.2[illegible]	2.20	2.15	2.19	2.07	2.04	0.64	by concrete between February 11 and March 5, 1879.
16	13	1.21	1.22	2,64	2.58	2.55	2.45	2.21	2.16	2.09	2.09	2.02	1.99	0.65	
17	14	1.09	1.09	2.53	2.45	2.48	2.38	2.1[illegible]	2.10	2.01	2.01	1.90	1.88	1.88	Station 104.
18	15	1.11	1.08	2.43	2.36	2.34	2.25	2,0[illegible]	1.96	1.87	1.87	1.78	1.76	0.67	
19	16	0.86	0.87	2.22	2.15	2.14	2.06	1.81	1.77	1.68	1.68	1.59	1.57	0.65	
20	17	2.10	2.05	2.01	1.98	1.99	1.87	1.6[illegible]	1.56	1.45	1.44	1.38	1.37	0.73	
21	18	2.03	1.99	1.93	1.91	1.89	1.82	1.5[illegible]	1.48	1.36	1.37	1.30	1.30	0.73	
22	Feb. 1	2.75	2.63	2.55	2.53	2.49	2.41	2.07	1.94	1.74	1.72	1.69	1.63	1.12	
23	1	2.77	2.65	2.62	2.57	2.54	2.46	2.1[illegible]	2.08	1.92	1.93	1.84	1.84	0.93	Station 105.
24	3	2.84	2.73	2.64	2.60	2.60	2.58	2.2[illegible]	2.17	2.06	2.06	1.99	1.99	0.85	
25	4	2.84	2.68	2.60	2.56	2.54	2.45	2.1	2.12	1.99	1.99	1.90	1.89	0.95	
26	5	....	2.45	2.38	2.33	2.31	2.22	1.9[illegible]	1.89	1.81	1.80	1.71	1.70	0.75	
27	5	....	2.62	2.54	2.43	2.48	2,39	2.1[illegible]	2.04	1.92	1.90	1.79	1.79	0.83	
28	6	....	2.66	2.56	2.45	2.49	2.32	1.8[illegible]	1.75	1.63	1.61	1.50	1.50	1.16	

EAST JETTY—BELOW STATION 101+15—Continued.

No. of block.	Date when laid.	Elevation, February 4, 1879.	Elevation, February 11, 1880.	Elevation, March 5, 1879.	Elevation, March 31, 1879.	Elevation, April 28, 1879.	Elevation, July 1, 1879.	Elevation, September 9, 1879.	Elevation, October 17, 1879.	Elevation, November 26, 1879.	Elevation, December 27, 1879.	Elevation, January 28, 1880.	Elevation, February 27, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
29	Feb. 6	....	2.57	2.45	2.38	2.36	2.15	1.46	1.37	1.28	1.26	1.17	1.17	1.40	Station 106.
30	7	....	2.54	2.45	2.38	2.38	2.21	1.78	1.68	1.57	1.55	1.44	1.43	1.11	
31	7	....	2.60	2.54	2.49	2.50	2.38	2.07	1.95	1.84	1.82	1.69	1.67	0.93	
32	7	....	2.60	2.51	2.51	2.45	2.32	2.01	1.92	1.79	1.76	1.65	1.62	0.98	
33	8	....	2.46	2.35	2.32	2.31	2.16	1.88	1.79	1.69	1.65	1.54	1.52	0.94	
34	8	....	2.46	2.34	2.33	2.29	2.15	1.81	1.76	1.59	1.51	1.36	1.33	1.13	
35	10	..	2.63	2.47	2.50	2.48	2.33	2.03	1.90	1.43	1.34	1.18	1.14	1.49	Station 107.
36	10	....	....	2.59	2.58	2.54	2.40	2.11	1.93	1.74	1.68	1.62	1.58	1.01	
37	10	....	....	2.63	2.62	2.59	2.47	2.19	2.06	1.92	1.86	1.75	1.71	0.92	
38	12	....	....	2.62	2.63	2.61	2.47	2.19	2.11	1.98	1.91	1.81	1.76	0.86	
39	12	....	....	2.46	2.58	2.47	2.30	2.02	1.95	1.79	1.73	1.62	1.57	0.89	
40	12	..	...	2.37	2.34	2.30	2.09	1.82	1.76	1.68	1.63	1.56	1.53	0.84	
41	12	....	....	2.35	2.32	2.25	2.05	1.77	1.71	1.61	1.57	1.47	1.44	0.91	
42	15	....	....	2.52	2.56	2.45	2.31	2.02	1.95	1.85	1.81	1.63	1.59	0.93	Station 108.
43	15	....	..	2.64	2.66	2.58	2.45	2.16	2.08	1.99	1.95	1.83	1.79	0.85	
44	15	....	....	2.78	2.76	2.71	2.59	2.29	2.19	2.08	2.04	1.92	1.90	0.88	
45	17	....	....	2.77	2.71	2.67	2.56	2.24	2.14	2.04	2.01	1.89	1.85	0.92	
46	17	....	....	2.81	2.77	2.73	2.65	2.34	2.23	2.12	2.09	1.96	1.94	0.87	
47	18	....	....	2.91	2.88	2.84	2.75	2.44	2.33	2.20	2.17	2.01	1.98	0.93	
48	18	....	....	2.90	2.85	2.81	2.71	2.40	2.30	2.08	2.05	1.82	1.78	1.12	Station 109.
49	18	....	....	2.85	2.81	2.76	2.67	2.36	2.22	1.86	1.83	1.71	1.68	1.17	
50	19	....	....	2.75	2.69	2.52	2.43	2.10	1.96	1.82	1.81	1.72	1.69	1.06	
51	19	....	....	2.83	2.77	2.77	2.57	2.23	2.14	2.03	2.01	1.93	1.90	0.93	
52	19	....	..	2.81	2.78	2.77	2.59	2.29	2.19	2.07	2.06	1.90	1.87	0.94	
53	20	....	....	2.67	2.73	2.71	2.50	2.19	2.10	1.97	1.99	1.82	1.77	0.90	
54	20	....	....	2.65	2.60	2.58	2.38	2.05	1.96	1.84	1.83	1.66	1.61	1.04	Station 110.
55	21	....	....	2.67	2.60	2.57	2.40	2.07	1.99	1.86	1.86	1.78	1.74	0.93	
56	22	....	....	2.69	2.61	2.59	2.42	2.11	2.02	1.89	1.89	1.80	1.75	0.94	
57	22	....	....	2.68	2.58	2.56	2.41	2.10	2.01	1.87	1.86	1.80	1.75	0.93	
58	24	....	....	2.72	2.65	2.62	2.48	2.18	2.08	1.94	1.93	1.80	1.77	0.95	
59	24	....	...	2.66	2.56	2.53	2.38	2.09	1.98	1.86	1.83	1.76	1.72	0.94	
60	26	....	....	2.76	2.67	2.58	2.43	2.12	2.01	1.88	1.86	1.80	1.75	1.01	Station 111.
61	Mar. 1	....	....	2.76	2.63	2.66	2.46	2.08	2.01	1.87	1.83	1.75	1.71	1.05	
62	3	....	....	2.66	2.60	2.56	2.43	2.11	1.99	1.86	1.81	1.71	1.67	0.99	
63	3	....	....	2.77	2.63	2.53	2.46	2.14	2.02	1.90	1.84	1.75	1.71	1.06	
64	4	....	....	2.79	2.66	2.65	2.51	2.18	2.07	1.94	1.88	1.76	1.73	1.06	
65	4	....	...	2.75	2.56	2.54	2.46	2.16	2.05	1.93	1.91	1.83	1.81	0.94	
66	4	....	....	2.70	2.53	2.54	2.47	2.20	2.10	1.99	1.97	1.84	1.82	0.88	Station 112.
67	5	....	....	2.67	2.43	2.46	2.33	2.04	1.93	1.79	1.74	1.64	1.61	1.06	
68	5	....	....	....	2.43	2.39	2.28	1.94	1.88	1.72	1.66	1.54	1.51	0.92	
69	5	....	....	...	2.55	2.50	2.40	2.11	1.99	1.82	1.77	1.66	1.64	0.91	
70	7	..	....	..	2.57	2.54	2.40	2.14	1.98	1.79	1.75	1.66	1.60	0.97	
71	7	....	....	....	2.61	2.53	2.45	2.11	2.00	1.80	1.74	1.62	1.60	1.01	
72	7	..	....	....	2.61	2.57	2.46	2.15	2.02	1.81	1.77	1.67	1.65	0.96	
73	7	...	...	....	3.06	3.04	2.95	2.64	2.50	2.30	2.28	2.22	2.20	0.86	Station 113.
74	8	....	....	...	3.12	3.07	3.03	2.72	2.56	2.36	2.37	2.28	2.26	0.86	
75	8	....	....	..	3.15	3.19	3.08	2.77	2.61	2.41	2.41	2.33	2.30	0.85	
76	8	....	....	....	3.19	3.18	3.13	2.83	2.69	2.50	2.49	2.41	2.39	0.80	
77	10	....	..	....	3.35	3.38	3.35	3.05	2.94	2.69	2.70	2.62	2.58	0.77	
78	11	....	...	....	3.43	3.37	3.42	3.12	2.96	2.83	2.85	2.77	2.73	0.70	
79	11	....	....	....	3.53	3.52	3.49	3.19	3.09	2.86	2.88	2.80	2.78	0.75	Station 114.
80	11	....	....	...	3.51	3.49	3.47	3.15	3.04	2.85	2.84	2.75	2.69	0.82	
81	12	....	....	....	3.39	3.39	3.37	3.01	2.91	2.73	2.73	2.61	2.56	0.83	
82	12	....	....	....	3.38	3.38	3.33	2.99	2.90	2.73	2.75	2.63	2.60	0.78	
83	12	....	....	....	3.36	3.34	3.31	2.93	2.84	2.66	2.69	2.58	2.55	0.81	
84	13	....	....	....	3.38	3.34	3.30	2.94	2.83	2.66	2.68	2.59	2.55	0.83	
85	13	....	....	....	3.52	3.51	3.48	3.11	3.06	2.90	2.92	2.82	2.80	0.72	Station 115.
86	14	....	....	....	3.98	3.91	3.92	3.56	3.44	3.28	3.30	3.22	3.15	0.83	
87	14	....	....	....	4.13	4.07	4.05	3.66	3.54	3.36	3.37	3.31	3.29	0.84	
88	15	....	....	....	4.18	4.08	4.07	3.62	3.42	3.24	3.25	3.17	3.13	1.05	
89	15	....	...	....	4.17	4.09	3.92	3.45	3.20	2.91	2.95	2.76	2.72	1.45	
90	18	....	...	....	4.32	4.14	3.97	3.10	2.75	2.51	2.49	2.29	2.28	2.04	
91	19	...	....	....	4.30	3.48	3.21	2.76	2.69	....	....	2.12	2.04	2.26	Station 116. Block 91 was undermined by waves and broken in two.
	1880.														
92	June 8														
93	29 and 30	*....	....	....	....	....	....	....	....	....	....	....	....	....	
94	July 2 and 6														
	Average subsidence of 90 blocks													0.89	
	Greatest subsidence, Station 116													2.26	

* No levels taken previous to July 1, 1880.

EAST JETTY—ABOVE STATION 101 + 15—Continued.

No. of block.	Date when laid.	Elevation July 1, 1879.	Elevation September 9, 1879.	Elevation October 17, 1879.	Elevation November 26, 1879.	Elevation December 27, 1879.	Elevation January 28, 1880.	Elevation February 24, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
1	May 29	2.67	2.40	2.34	2.30	2.24	......	......	0.43	Station 101.
2	29	2.49	2.22	2.17	2.11	2.07	......	......	0.42	The construction of the parapet prevented the taking of levels on numbers 1 to 12 after December 27, 1879, and on numbers succeeding after February 24, 1880.
3	30	2.38	2.12	2.06	2.01	1.95	......	......	0.43	
4	30	2.41	2.14	2.07	2.00	1.94	......	......	0.47	
5	30	2.34	2.04	1.97	1.93	1.86	......	......	0.48	
6	30	2.38	2.10	2.05	2.00	1.93	......	......	0.45	
7	June 2	2.29	2.01	1.96	1.89	1.82	......	......	0.47	
8	2	2.24	1.95	1.87	1.84	1.75	......	......	0.49	
9	2	2.12	1.83	1.74	1.70	1.65	......	......	0.47	Station 99.
10	2	2.30	2.00	1.90	1.87	1.79	......	......	0.51	
11	2	2.32	2.00	1.92	1.87	1.80	......	......	0.52	
12	2	2.40	2.10	2.01	1.95	1.88	......	......	0.52	
13	5	2.42	2.14	2.05	2.00	1.94	......	1.77	0.65	Station 98.
14	5	2.31	2.02	1.95	1.90	1.85	......	1.75	0.56	
15	6	2.47	2.22	2.16	2.06	2.02	......	1.92	0.55	
16	6	2.66	2.39	2.30	2.26	2.25	......	2.13	0.53	
17	6	2.58	2.41	2.33	2.29	2.28	......	2.18	0.40	
18	9	2.43	2.27	2.18	2.16	2.16	......	2.03	0.40	Station 97.
19	9	2.29	2.12	2.05	2.02	2.00	......	2.03	0.29	
20	9	2.25	2.10	2.02	1.98	1.98	......	2.21	0.27	Station numbers 19 to 27, inclusive, raised by concrete January 1880.
21	11	2.38	2.20	2.13	2.12	2.09	......	2.32	0.29	
22	11	2.50	2.34	2.27	2.26	2.22	......	2.31	0.28	
23	11	2.54	2.41	2.33	2.32	2.29	......	2.29	0.25	Station 96.
24	11	2.51	2.44	2.36	2.36	2.33	......	2.47	0.28	Subsidence of numbers 19 to 27, inclusive, is up to December 27, 1879.
25	11	2.30	2.32	2.26	2.25	2.21	......	2.35	0.09	
26	11	2.16	2.12	2.07	2.06	2.04	......	2.23	0.12	
27	11	2.25	2.20	2.14	2.13	2.11	......	2.16	0.14	
28	12	2.45	2.43	2.36	2.35	2.34	......	2.21	0.24	Station 95.
29	12	2.51	2.53	2.47	2.45	2.45	......	2.32	0.19	
30	12	2.46	2.47	2.43	2.38	2.36	......	2.27	0.19	
31	12	2.53	2.38	2.38	2.32	2.32	......	2.28	0.25	
32	12	2.35	2.16	2.07	2.02	2.04	......	2.00	0.35	
33	12	2.40	2.14	1.99	1.89	1.89	......	1.80	0.60	
34	12	2.34	1.86	1.80	1.71	1.71	......	1.77	0.57	Station 93 + 96.
35	Dec. 15	......	......	......	......	2.35	......	2.46	......	
36	15	......	......	......	......	2.56	......	2.80	......	
37	15	......	......	......	......	2.55	......	2.50	0.05	
38	15	......	......	......	......	2.45	......	2.36	0.09	Station 93.
39	15	......	......	......	......	2.60	......	2.47	0.13	
40	16	......	......	......	......	2.81	......	2.58	0.23	
41	16	......	......	......	......	2.66	......	2.30	0.36	
42	16	......	......	......	......	2.71	......	2.38	0.33	
43	16	......	......	......	......	2.60	......	2.28	0.32	Station 92.
44	16	......	......	......	......	2.48	......	2.15	0.33	
45	18	......	......	......	......	2.63	......	2.28	0.35	
46	18	......	......	......	......	2.82	......	2.38	0.44	
47	18	......	......	......	......	2.66	......	2.42	0.24	Station 91.
48	18	......	......	......	......	2.62	......	2.24	0.38	
49	18	......	......	......	......	2.53	......	2.14	0.39	
50	20	......	......	......	......	2.63	......	2.24	0.39	
51	20	......	......	......	......	2.56	......	2.18	0.38	
52	20	......	......	......	......	2.33	......	2.15	0.18	Station 90.
53	20	......	......	......	......	2.28	......	1.96	0.32	
54	20	......	......	......	......	2.39	......	2.22	0.17	
55	20	......	......	......	......	2.46	......	2.11	0.35	
56	20	......	......	......	......	2.45	......	2.17	0.28	
57	24	......	......	......	......	2.71	......	2.45	0.26	Station 89.
58	24	......	......	......	......	2.78	......	2.51	0.27	
59	24	......	......	......	......	2.76	......	2.50	0.26	
60	24	......	......	......	......	2.95	......	2.63	0.32	
	1880.									
61	Jan. 10	......	......	......	......	......	......	2.12	......	
	1879.									
62	Dec. 24	......	......	......	......	2.56	......	2.47	0.09	Station 88.
63	27	......	......	......	......	2.45	......	2.42	0.03	
64	27	......	......	......	......	2.61	......	2.49	0.12	
65	27	......	......	......	......	2.67	......	2.60	0.07	
66	27	......	......	......	......	2.79	......	2.56	0.23	
67	29	......	......	......	......	2.63	......	2.37	0.26	Station 87.
68	29	......	......	......	......	2.48	......	2.19	0.29	
69	29	......	......	......	......	2.60	......	2.25	0.35	
70	29	......	......	......	......	2.82	......	2.53	0.29	
71	29	......	......	......	......	......	......	2.58	......	

EAST JETTY—ABOVE STATION 101 + 15—Continued.

No. of block.	Date when laid.	Elevation July 1, 1879.	Elevation September 9, 1879.	Elevation October 17, 1879.	Elevation November 26, 1879.	Elevation December 27, 1879.	Elevation January 28, 1880.	Elevation February 24, 1880.	Total subsidence.	Remarks.
	1880.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	
72	Jan. 1							2.32		Station 86.
73	1							2.20		
74	1							2.14		
75	1							2.11		
76	1							2.07		
77	2							2.22		Station 85.
78	2							2.34		
79	2							2.21		
80	9							1.91		
81	9							2.05		Station 84.
82	9							2.24		
83	9							2.20		
84	9							2.10		
85	10							1.90		
86	10							2.00		Station 83.
87	10							2.11		
88	10							1.93		
89	10							1.85		
90	12							2.08		
91	12							2.33		Station 82.
92	12							1.97		
93	12							2.00		
94	23							2.39		
95	23							2.09		
96	27							2.18		Station 81.
97	27							2.29		
98	27							2.08		
99	27							2.01		
100	28							2.03		
101	28							2.43		Station 80.
102	28							1.94		
103	28							1.93		
104	29							2.26		
105	29							2.38		
106	29							2.58		Station 79.
107	29							3.03		
108	29							3.13		
109	Feb. 4							2.73		
110	4							2.67		
111	7							2.63		Station 78.
112	7							2.64		
113	7							2.75		
114	9							2.84		
115	9							2.92		Station 77.
116	9							2.64		
117	9							3.03		
118	9							3.21		
119	10							3.04		
120	10							3.13		Station 76.
121	10							3.14		
122	10							2.95		
123	10							2.90		
124	10							2.90		
125	10							2.53		Station 75.
126	12							2.73		
127	12							2.61		
128	12							2.40		
129	12							2.74		
130	12							2.60		Station 74.
131	16							2.60		
132	16							2.59		
133	16							2.62		
134	16							2.62		
135	16							2.56		Station 73.
136	18							2.45		
137	18							2.46		
138	20							2.56		
139	20							2.62		
140	20							2.40		Station 72.
141	20							2.56		
142	21							2.28		
143	21							2.37		
144	21							2.47		

EAST JETTY—ABOVE STATION 101+15—Continued.

No. of block.	Date when laid.	Elevation July 1, 1879.	Elevation September 9, 1879.	Elevation October 17, 1879.	Elevation November 26, 1879.	Elevation December 27, 1879.	Elevation January 28, 1880.	Elevation February 24, 1880.	Total subsidence.	Remarks.
	1880.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
145	Feb. 21	......	......	......	......	......	......	2.44	......	Station 71.
146	21	......	......	......	......	......	......	2.22	......	
147	23	......	......	......	......	......	......	2.06	......	
148	23	......	......	......	......	......	......	2.25	......	
149	23	......	......	......	......	......	......	2.51	......	
150	23	......	......	......	......	......	......	2.45	......	Station 70.
151	23	......	......	......	......	......	......	2.26	......	
152	23	......	......	......	......	......	......	2.27	......	
153	26	......	......	......	......	......	......	2.49	......	
154	26	......	......	......	......	......	......	2.41	......	
155	26	......	......	......	......	......	......	2.34	......	Station 69.
156	26	......	......	......	......	......	......	2.66	......	
157	26	......	......	......	......	......	......	2.77	......	
158	Mar. 10	......	......	......	......	......	......	2.47	......	
159	10	......	......	......	......	......	......	2.40	......	
160	10	......	......	......	......	......	......	2.51	......	Station 68.
161	11	......	......	......	......	......	......	2.76	......	
162	11	......	......	......	......	......	......	2.96	......	
163	11	......	......	......	......	......	......	2.80	......	
164	11	......	......	......	......	......	......	2.79	......	
165	11	......	......	......	......	......	......	2.69	......	Station 67.
166	11	......	......	......	......	......	......	2.65	......	
167	17	......	......	......	......	......	......	2.90	......	
168	17	......	......	......	......	......	......	3.14	......	
169	17	......	......	......	......	......	......	3.33	......	
170	17	......	......	......	......	......	......	3.29	......	Station 66.
171	18	......	......	......	......	......	......	3.56	......	
172	18	......	......	......	......	......	......	3.43	......	
173	18	......	......	......	......	......	......	3.40	......	
174	18	......	......	......	......	......	......	3.44	......	Station 65+15.
		Average subsidence of 67 blocks							0.32	
		Greatest subsidence, Station 94							0.60	

WEST JETTY—BELOW STATION 101 + 25.

No. of block.	Date when laid.	Elevation February 4, 1879.	Elevation February 11, 1879.	Elevation March 5, 1879.	Elevation March 31, 1879.	Elevation April 28, 1879.	Elevation July 1, 1879.	Elevation September 18, 1879.	Elevation October 17, 1879.	Elevation December 29, 1879.	Elevation January 27, 1880.	Elevation February 27, 1880.	Elevation March 31, 1880.	Elevation June 23, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
1	Jan. 31	2.23	2.09	2.03	1.91	....	....	2.43	2.41	2.35	2.40	2.38	2.37	2.33	0.10	Station 101 + 25.
2	30	2.11	2.00	1.95	1.86	....	....	2.39	2.37	2.30	2.36	2.35	2.32	2.28	0.11	Nos. 1 to 5, inclusive,
3	30	1.74	1.66	1.56	1.54	....	..	2.46	2.44	2.40	2.34	2.31	2.30	2.27	0.19	raised by concrete April
4	29	1.96	1.87	1.83	1.73	....	....	2.60	2.58	2.52	2.49	2.47	2.46	2.44	0.16	1879.
5	29	2.23	2.12	2.07	2.00	....	....	2.86	2.83	2.76	2.72	2.70	2.71	2.66	0.20	Station 102.
6	28	2.41	2.37	2.31	2.18	....	....	....		..	..	...	...	...	...	Under mixer.
7	21	2.19	2.06	2.03	2.10	....	....	1.83	1.81	1.75	1.72	1.72	1.71	1.72	0.47	
8	22	2.06	1.97	1.93	1.95	1.92	1.83	1.65	1.63	1.55	1.54	1.56	1.56	1.54	0.52	
9	23	2.01	1.92	1.88	1.83	1.82	1.74	1.59	1.56	1.49	1.48	1.47	1.45	1.44	0.57	
10	23	2.05	1.98	1.91	1.87	1.80	1.78	1.62	1.60	1.52	1.51	1.51	1.49	1.47	0.58	
11	24	2.18	2.08	2.01	1.96	1.96	1.90	1.75	1.72	1.66	1.62	1.60	1.59	1.57	0.61	
12	25	2.37	2.28	2.18	2.11	2.13	2.08	1.93	1.91	1.84	1.81	1.80	1.79	1.78	0.59	Station 103.
13	27	2.64	2.54	2.53	2.43	2.42	2.36	2.22	2.20	2.14	2.13	2.12	2.11	2.10	0.54	
14	27	2.68	2.57	2.48	2.44	2.44	2.38	2.30	2.27	2.22	2.15	2.13	2.12	2.11	0.57	
15	31	2.85	2.71	2.65	2.60	2.60	2.56	2.44	2.42	2.38	2.35	2.32	2.31	2.30	0.55	
16	Feb. 1	....	....	....	2.65	2.65	2.62	2.50	2.43	2.32	2.29	2.26	2.24	2.23	0.42	
17	Mar. 21	....	..	...	2.85	2.86	2.85	2.75	2.72	2.68	2.68	2.65	2.66	2.65	0.20	
18	21	....	....	..	2.84	2.84	2.86	2.74	2.72	2.6-	2.67	2.64	2.62	2.62	0.22	
19	21	...	....	....	2.87	2.83	2.80	2.69	2.66	2.62	2.60	2.58	2.56	2.55	0.32	Station 104.
20	21	..	..	...	2.89	2.86	2.81	2.68	2.65	2.61	2.57	2.55	2.53	2.53	0.36	
21	21	..	....	....	2.92	2.88	2.84	2.73	2.70	2.67	2.63	2.6[illegible]	6.60	2.59	0.43	
22	24	....	....	...	2.86	2.82	2.84	2.63	2.60	2.57	2.54	2.53	2.51	2.50	0.36	
23	24	....	....	....	2.80	2.74	2.66	2.55	2.51	2.48	2.44	2.45	2.42	2.42	0.38	
24	24	....	..	...	2.79	2.71	2.62	2.49	2.46	2.41	2.38	2.38	2.36	2.35	0.44	Station 105.
25	24	...	..	....	2.77	2.67	2.57	2.44	2.41	2.36	2.32	2.32	2.30	2.28	0.49	
26	24	....	....	....	2.65	2.57	2.46	2.33	2.29	2.24	2.19	2.18	2.17	2.16	0.49	
27	25	..	....	....	2.69	2.62	2.52	2.36	2.34	2.29	2.22	2.25	2.22	2.22	0.47	

WEST JETTY—BELOW STATION 101+25—Continued.

No.	Date when laid.	Elevation February 4, 1879.	Elevation February 11, 1879.	Elevation March 5, 1879.	Elevation March 31, 1879.	Elevation April 28, 1879.	Elevation July 1, 1879.	Elevation September 18, 1879.	Elevation October 17, 1879.	Elevation December 29, 1879.	Elevation January 27, 1880.	Elevation February 27, 1880.	Elevation March 31, 1880.	Elevation June 23, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
[illegible]	Mar. 25	....	....	..	2.81	2.74	2.63	2.49	2.46	2.41	2.37	2.36	2.36	2.35	0.46	
[illegible]	25	....	....	....	2.93	2.87	2.75	2.61	2.60	2.53	2.50	2.48	2.48	2.48	0.45	
[illegible]	25	....	....	....	2.97	2.97	2.86	2.73	2.70	2.64	2.60	2.60	2.59	2.58	0.39	
[illegible]	26	....	....	....	3.12	3.06	2.94	2.80	2.78	2.71	2.67	2.66	2.65	2.65	0.47	Station 106.
[illegible]	26	....	....	....	3.12	3.04	2.91	2.76	2.75	2.67	2.65	2.64	2.63	2.62	0.50	
[illegible]	26	....	....	....	3.14	3.06	2.91	2.76	2.74	2.66	2.64	2.62	2.62	2.61	0.53	
34	26	....	....	..	3.24	3.16	3.01	2.86	2.83	2.75	2.75	2.72	2.72	2.72	0.52	
35	26	....	....	....	3.22	3.15	3.00	2.85	2.83	2.75	2.75	2.73	2.72	2.73	0.49	
36	27	....	....	....	3.23	3.14	3.00	2.86	2.84	2.81	2.72	2.69	2.67	2.67	0.56	
[illegible]	27	....	....	....	3.31	3.20	3.10	2.95	2.94	2.85	2.86	2.83	2.82	2.81	0.50	Station 107.
[illegible]	27	....	....	....	3.30	3.18	3.12	2.97	2.95	2.87	2.82	2.80	2.78	2.79	0.51	
[illegible]	27	....	....	....	3.21	3.11	3.07	2.93	2.92	2.85	2.84	2.80	2.79	2.80	0.41	
40	27	....	....	....	3.11	3.03	2.97	2.84	2.83	2.76	2.75	2.71	2.70	2.70	0.41	
[illegible]	28	....	....	....	3.04	2.96	2.91	2.76	2.74	2.66	2.66	2.63	2.61	2.64	0.40	
[illegible]	28	....	....	....	3.07	2.95	2.88	2.71	2.68	2.60	2.57	2.54	2.51	2.53	0.54	
[illegible]	28	....	....	...	3.12	3.00	2.89	2.72	2.69	2.62	2.57	2.54	2.52	2.49	0.63	Station 108.
44	29	....	....	....	3.18	3.05	2.98	2.81	2.78	2.70	2.64	2.63	2.62	2.60	0.58	
[illegible]	29	....	....	....	3.23	3.11	3.05	2.83	2.80	2.63	2.58	2.56	2.53	2.52	0.71	
[illegible]	29	....	....	....	3.26	3.06	3.00	2.80	2.76	2.62	2.57	2.55	2.51	2.43	0.83	
[illegible]	29	....	....	....	3.21	2.93	2.85	2.62	2.53	2.33	2.25	2.23	2.20	2.17	1.04	
[illegible]	31	....	....	....	3.24	2.91	2.75	2.59	2.55	2.40	2.32	2.30	2.29	2.27	0.97	
[illegible]	31	....	....	....	3.31	2.86	2.76	2.55	2.49	2.15	2.12	2.08	2.06	1.99	1.32	Station 109.
50	31	....	....	....	(*) 3.10	2.77	2.67	2.47	2.40	2.19	2.15	2.14	2.11	2.05	1.05	
51	31	....	....	....	3.20	2.94	2.85	2.71	2.63	2.53	2.50	2.48	2.47	2.44	0.76	
[illegible]	31	....	....	....	3.25	2.96	2.88	2.76	2.74	2.62	2.52	2.47	2.45	2.44	0.81	
[illegible]	Apr. 1	....	....	....	3.37	3.08	3.01	2.86	2.85	2.75	2.71	2.68	2.67	2.66	0.71	
54	1	....	....	....	3.32	3.05	2.97	2.79	2.76	2.65	2.67	2.65	2.63	2.62	0.70	
55	1	....	....	...	3.26	3.03	2.92	2.74	2.71	2.58	2.60	2.57	2.55	2.51	0.75	
[illegible]	1	....	....	....	3.15	3.04	2.75	2.61	2.57	2.47	2.50	2.47	2.45	2.38	0.77	Station 110.
[illegible]	2	....	....	....	3.25	3.07	2.93	2.76	2.71	2.59	2.62	2.60	2.58	2.50	0.75	
[illegible]	2	....	....	....	3.23	3.06	2.94	2.75	2.71	2.58	2.56	2.55	2.52	2.46	0.77	
[illegible]	2	....	....	....	3.15	3.00	2.89	2.68	2.66	2.51	2.52	2.50	2.49	2.42	0.77	
[illegible]	2	..	....	....	3.05	2.99	2.87	2.62	2.61	2.49	2.44	2.43	2.40	2.36	0.69	
61	3	....	....	....	3.12	2.98	2.86	2.66	2.62	2.50	2.47	2.46	2.43	2.39	0.73	
[illegible]	3	....	..	....	3.16	3.03	2.93	2.74	2.71	2.58	2.55	2.55	2.53	2.48	0.68	Station 111.
[illegible]	3	....	....	....	3.31	3.09	3.00	2.82	2.79	2.67	2.66	2.65	2.62	2.60	0.71	
[illegible]	5	....	....	....	3.40	3.27	3.15	2.99	2.96	2.86	2.82	2.80	2.78	2.75	0.65	
[illegible]	5	....	....	...	3.46	3.35	3.26	3.10	3.08	2.95	2.90	2.88	2.87	2.84	0.62	
[illegible]	7	....	....	....	3.61	3.40	3.37	3.22	3.19	3.09	3.06	3.05	3.02	3.02	0.59	
[illegible]	8	....	....	....	3.22	3.03	3.44	3.20	3.15	3.05	3.00	2.99	2.96	2.93	0.51	Station 112.
[illegible]	8	....	....	....	3.22	3.08	3.51	2.83	2.76	2.66	2.63	2.61	2.57	2.56	0.95	Blocks 67 to 72, inclusive, were tilted by gale April 23, 1879, and when restored to horizontal position were found to be above original elevation.
[illegible]	8	....	....	....	3.27	3.02	3.51	3.12	2.98	2.86	2.80	2.78	2.77	2.74	0.77	
[illegible]	8	....	....	....	3.10	2.98	3.42	3.15	3.11	3.00	2.96	2.93	2.90	2.88	0.54	
[illegible]	8	....	....	....	3.04	2.89	3.42	3.31	3.30	3.19	3.14	3.11	3.09	3.07	0.35	
[illegible]	8	....	....	....	....	2.92	3.38	3.34	3.33	3.21	3.17	3.14	3.12	3.09	0.29	
[illegible]	10	....	....	....	....	....	3.27	3.20	3.18	3.07	3.02	2.99	2.97	2.89	0.38	
[illegible]	11	....	....	....	....	....	3.37	3.19	3.17	3.05	3.01	2.98	2.95	2.81	0.56	Station 113.
[illegible]	11	....	....	....	....	....	3.44	3.26	3.24	3.11	3.02	3.03	3.01	2.92	0.52	
[illegible]	11	....	....	....	....	..	3.46	3.27	3.26	3.14	3.11	3.07	3.04	3.00	0.46	
[illegible]	17	....	....	....	....	....	3.54	3.38	3.36	3.21	3.18	3.14	3.12	3.05	0.49	
[illegible]	18	....	....	....	....	....	3.61	3.41	3.37	3.23	3.20	3.16	3.14	3.12	0.49	
[illegible]	June 30	....	....	....	....	....	3.50	3.01	2.94	2.71	2.67	2.63	2.62	2.57	0.93	
[illegible]	14	....	....	....	....	....	2.96	2.65	2.61	2.43	2.40	2.36	2.34	2.28	0.68	
[illegible]	14	....	....	....	....	....	2.81	2.68	2.63	2.46	2.44	2.40	2.37	2.31	0.50	
[illegible]	16	....	....	....	....	....	2.97	2.71	2.65	2.50	2.47	2.43	2.42	2.37	0.60	Station 114.
[illegible]	16	....	....	....	....	....	3.05	2.75	2.70	2.51	2.48	2.45	2.44	2.39	0.66	
[illegible]	16	....	....	....	....	....	3.00	2.69	2.63	2.44	2.41	2.37	2.35	2.31	0.69	
[illegible]	17	....	....	....	....	....	2.85	2.72	2.67	2.49	2.45	2.43	2.41	2.36	0.49	
[illegible]	17	....	....	....	....	....	2.92	2.67	2.50	2.42	2.36	2.34	2.34	2.23	0.69	
[illegible]	17	....	....	....	....	....	2.78	2.68	2.63	2.43	2.38	2.35	2.34	2.26	0.52	
[illegible]	18	....	....	....	....	....	2.84	2.72	2.66	2.45	2.40	2.37	2.36	2.27	0.57	Station 115.
[illegible]	18	....	....	....	....	..	2.98	2.77	2.71	2.48	2.44	2.41	2.41	2.32	0.66	
[illegible]	18	....	....	....	....	....	2.99	2.77	2.69	2.48	2.39	2.35	2.40	2.31	0.68	
[illegible]	19	....	....	....	....	....	2.92	2.67	2.58	2.37	2.34	2.30	2.29	2.20	0.72	
[illegible]	19	....	....	....	....	....	2.95	2.65	2.57	2.38	2.34	2.30	2.30	2.21	0.74	
[illegible]	19	....	....	....	....	..	2.93	2.48	2.46	2.33	2.29	2.23	2.26	2.09	0.84	
[illegible]	20	....	....	....	....	....	3.53	2.99	2.89	2.84	2.77	2.76	2.73	2.52	1.01	Station 116.
[illegible]	20	....	....	....	....	....	3.50	3.10	3.05	2.84	2.82	2.78	2.80	2.67	0.83	
[illegible]	July 1	....	....	....	....	....	3.47	3.05	2.99	2.75	2.72	2.65	2.64	2.35	1.12	
	Average subsidence of 95 blocks														0.65	
	Greatest subsidence, Station 116 + 59														1.12	

*April 18.

WEST JETTY—ABOVE STATION 101+25—Continued.

Number of block.	Date when laid.	Elevation September 18, 1879.	Elevation October 17, 1879.	Elevation December 29, 1879.	Elevation January 27, 1880.	Elevation February 27, 1880.	Elevation March 31, 1880.	Elevation June 23, 1880.	Total subsidence.	Remarks.
	1879.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
1	May 7	2.68	2.67	2.61	2.59	2.59	2.57	2.54	0.14	Station 101.
2	8	2.79	2.77	2.70	2.75	2.74	2.71	2.70	0.09	
3	8	2.77	2.75	2.68	2.70	2.69	2.67	2.66	0.11	
4	8	2.99	2.98	2.93	2.92	2.90	2.87	2.89	0.10	
5	9	3.21	3.19	3.13	3.10	3.07	3.05	2.89	0.32	
6	9	2.68	2.65	2.59	2.58	2.56	2.55	2.54	0.14	
7	9	2.34	2.32	2.23	2.23	2.21	2.20	2.17	0.17	
8	10	2.16	2.12	2.06	2.16	2.16	2.13	2.15	0.01	Station 100.
9	10	2.40	2.35	2.27	2.25	2.22	2.21	2.20	0.20	
10	12	2.33	2.29	2.29	2.29	2.28	2.26	2.24	0.09	
11	12	2.42	2.39	2.32	2.30	2.28	2.26	2.24	0.18	
12	12	2.42	2.40	2.32	2.31	2.30	2.29	2.26	0.16	
13	12	2.41	2.38	2.30	2.24	2.27	2.27	2.24	0.17	
14	13	2.35	2.31	2.24	2.22	2.20	2.20	2.17	0.18	Station 99.
15	13	2.29	2.25	2.18	2.16	2.15	2.14	2.11	0.18	
16	13	2.34	2.30	2.23	2.23	2.20	2.18	2.15	0.19	
17	13	2.44	2.40	2.34	2.33	2.31	2.30	2.27	0.17	
18	13	2.19	2.15	2.08	2.07	2.04	2.03	1.99	0.20	
19	13	2.27	2.22	2.15	2.13	2.10	2.08	2.05	0.22	
20	14	2.14	2.11	2.05	2.04	2.01	1.98	1.95	0.19	Station 98.
21	14	1.86	1.84	1.77	1.80	1.77	1.75	1.73	0.13	
22	14	1.74	1.71	1.65	1.64	1.61	1.60	1.57	0.17	
23	14	1.76	1.74	1.69	1.67	1.63	1.61	1.59	0.17	
24	14	1.76	1.77	1.68	1.76	1.72	1.70	1.68	0.08	
25	14	1.90	1.88	1.82	1.78	1.73	1.73	1.68	0.12	
26	14	1.65	1.63	1.57	1.60	1.55	1.54	1.51	0.14	Station 97.
27	14	1.67	1.65	1.68	1.59	1.55	1.53	1.49	0.18	
28	15	1.73	1.67	1.59	1.58	1.55	1.53	1.51	0.22	
29	15	1.69	1.61	1.56	1.53	1.49	1.48	1.45	0.24	
30	15	1.92	1.88	1.83	1.81	1.77	1.76	1.73	0.21	Station 96.
31	15	1.98	1.93	1.89	1.88	1.83	1.82	1.79	0.19	
32	15	2.03	1.98	1.94	1.93	1.89	1.88	1.85	0.18	
33	15	2.07	2.02	1.96	1.95	1.90	1.90	1.88	0.19	
34	16	2.01	1.95	1.88	1.89	1.85	1.85	1.81	0.20	Station 95.
35	16	2.06	2.01	1.96	1.95	1.93	1.93	1.88	0.18	
36	16	2.04	1.98	1.93	1.92	1.90	1.89	1.86	0.18	
37	16	1.87	1.84	1.83	1.79	1.78	1.77	1.73	0.14	
38	17	2.05	2.02	1.98	1.97	1.95	1.94	1.93	0.12	Station 94.
39	17	2.26	2.22	2.21	2.17	2.15	2.14	2.14	0.12	
40	17	2.45	2.41	2.38	2.43	2.40	2.39	2.38	0.07	
41	17	2.53	2.49	2.47	2.48	2.46	2.45	2.44	0.09	
42	19	2.52	2.48	2.46	2.47	2.45	2.44	2.42	0.10	Station 93.
43	19	2.54	2.50	2.49	2.48	2.45	2.43	2.43	0.11	
44	19	2.61	2.58	2.57	2.60	2.56	2.55	2.56	0.05	
45	20	2.50	2.49	2.47	2.57	2.55	2.53	2.34	0.06	
46	20	2.74	2.71	2.69	2.71	2.69	2.67	2.69	0.05	
47	20	2.68	2.67	2.65	2.62	2.59	2.57	2.58	0.10	Station 92.
48	20	2.52	2.50	2.47	2.53	2.50	2.49	2.49	0.03	
49	20	2.36	2.31	2.27	2.32	2.30	2.28	2.28	0.08	
50	20	2.33	2.28	2.23	2.23	2.21	2.21	2.21	0.12	
51	21	2.42	2.39	2.36	2.34	2.32	2.31	2.30	0.12	Station 91.
52	21	2.58	2.54	2.52	2.51	2.48	2.47	2.47	0.11	
53	21	2.69	2.64	2.61	2.60	2.57	2.55	2.54	0.15	
54	21	2.66	2.62	2.61	2.59	2.57	2.56	2.55	0.11	
55	21	2.38	2.35	2.32	2.29	2.27	2.25	2.25	0.13	Station 90.
56	21	1.92	1.88	1.85	1.79	1.78	1.78	1.79	0.13	
57	22	1.85	1.81	1.77	1.74	1.72	1.72	1.71	0.14	
58	22	2.04	2.00	1.95	1.92	1.91	1.87	1.90	0.14	
59	22	2.23	2.19	2.13	2.10	2.08	2.07	2.07	0.16	Station 88+97.
	Average subsidence of 59 blocks								0.14	
	Greatest subsidence, Station 100+50								0.32	

3d. *Building of parapet wall on concrete blocks.*—This wall above Station 101 + 82 is built of rubble stone with surface roughly dressed, and laid in mortar composed of two parts of sand to one of cement; it is 3 feet in width, and varies in height from 2.2 feet to 2.6 feet, according as the elevations of the underlying blocks require to make the upper surface of the parapet about 4.5 feet above average flood tide.

On June 30 there was 2,937 feet of this wall completed between Stations 65 + 15 and 101 + 82, leaving 730 feet to be built between Stations 87 + 20 and 94 + 50 to complete this wall over the concrete blocks in place above Station 101 + 82.

Below Station 102 + 15 this wall is built of concrete (the same as the foundation blocks) run into a continuous mold or trough built on the underlying blocks; it is

completed to Station 116+33, thus forming one solid block 1,418 feet long, 4 feet wide, and varying in thickness from 3.5 to 4 feet, according to the elevation of the underlying blocks. As this wall was built the spaces between the blocks were filled with concrete, thus consolidating this portion of the work.

The points at which levels were taken on the concrete blocks to determine their settlement could not of course be used or referred to after the parapet wall was built; and points were established 100 feet apart on the upper surface of the wall, and levels taken at these points.

Number of linear feet of rubble parapet built	2,937
Number of cubic yards of masonry	783
Number of linear feet of concrete parapet built	1,418
Number of cubic yards of concrete used	777

The extent of the above work is represented on Chart No. 2, and explained in a note thereon.

The following table gives the elevation and subsidence of the parapet wall at points 100 feet apart, from levels taken at various dates, referred to the plane of average flood tide:

Table giving elevation referred to average flood tide, and total subsidence of parapet wall.

Station.	Date when built.	Elevation May 10, 1880.	Elevation June 24, 1880.	Total subsidence.	Remarks.
	1880.				
65+15	April	4.61	4.47	0.14	Parapet from Station 65+15 to Station 87+20, and from Station 94+50 to Station 101+79, is built of rubble stone.
66+15	do	4.46	4.28	0.18	
67+15	do	4.58	4.53	0.05	
68+15	do	4.67	4.61	0.06	
69+15	do	4.60	4.56	0.04	
70+15	do	4.60	4.53	0.07	
71+15	do	4.72	4.66	0.06	
72+15	do	4.61	4.55	0.06	For the intermediate distance, 730 feet; this wall is in process of construction, but not finished July 1, 1880.
73+15	May	4.64	4.59	0.05	
74+15	do	4.63	4.63	0.00	
75+15	do	4.61	4.59	0.02	
76+15	do	4.67	4.65	0.02	
77+15	do	4.70	4.69	0.01	
78+15	do	4.65	4.65	0.00	
79+15	do	4.70	4.70	0.00	
80+15	do	4.49	4.47	0.02	
81+15	April	4.40	4.38	0.02	
82+15	do	4.56	4.55	0.01	
83+15	do	4.53	4.49	0.04	
84+15	do	4.59	4.55	0.04	
85+15	do	4.63	4.38	0.25	
86+15	do	4.60	4.42	0.18	
87+15	June	......	4.59	......	
96	do	....	4.60	......	
97	March	....	4.53	......	
		Elevation March 25, 1880.			
98	March	4.51	4.44	0.07	
99	February	4.35	4.20	0.15	
100	do	4.54	4.51	0.03	
101	January	4.64	4.57	0.07	
101+79	do	4.51	4.50	0.01	
103	June	......	5.24	......	Cement parapet commences at Station 102+15, and extends to 116+33.
104	do	......	5.19	......	
105	do	......	5.38	......	
106	March	......	5.40	......	
107	do	......	5.43	......	
108	do	......	5.49	......	
109	do	......	5.36	......	
110	April	......	5.56	......	
111	do	......	5.76	......	
112	do	......	5.91	......	
113	do	......	6.15	......	
114	do	......	6.22	......	
115	do	......	6.63	......	
115+90	June	......	6.81	......	

4th. Miscellaneous work.—On the sea side of the east jetty 254 cubic yards of stone have been placed between Stations 112 and 116 as a protection to the concrete blocks from the undermining action of the sea, which at some points has caused the blocks to tilt seaward slightly, and these blocks show the greatest depression, as will be seen by preceding tables.

From Station 75 to 80 116 cubic yards of gravel and 84 cubic yards of stone have been placed on the river side of the concrete blocks as a protection to their foundation, and 54 cubic yards of stone were used in preparing the foundation from Station 66 to 77. Between Stations 75 and 85 49 cubic yards of macadam and 44 cubic yards of gravel have been placed on the river side of the blocks; 15 cubic yards of macadam and 105 cubic yards of gravel have been placed on the river side between Stations 66 and 75; between Stations 63 and 65 the surface of the jetty has been covered by 108 cubic yards of marl, which was ballast material discharged from vessels here. Between the cribs at the end of the jetty 102 cubic yards of stone were placed.

The sand reef east of the east jetty (called base line reef) is about 400 feet further landward than it was February 3, 1879, and it has increased in area since February 13, last.

In consequence of the movement of this reef, before the concrete blocks were built, much sand was thrown over the jetty into the channel, causing it to shoal in that vicinity.

The present location of this reef is shown on Chart No. 2.

In order to hold this reef at its present junction with the jetty, 203 cords of willows weighted with 35 cubic yards of stone have been placed as represented on Chart No. 2.

(*b*.) WEST JETTY.

But little work has been done on this jetty during the year; three spur cribs have been placed on the sea side at Stations 112, 114, and 115, and four on the river side at Stations 110, 111, 111 + 80, and 113. Two palmetto cribs have been placed near but seaward of the end of the jetty. The construction of these cribs is the same as described for the east jetty; their location is shown on Chart No. 5, and their dimensions, &c., are given in the table concluding section 1 east jetty.

Above Station 89, or 4,820 feet below pile one, at which point the concrete blocks terminate, the work of raising the surface of this jetty was commenced August 27, 1879, at which time there was considerable leakage over the jetty at this point. The stone was first removed along the axis of the jetty, and placed temporarily on either side, leaving a trench from 5 to 7 feet wide, the bottom of which was the upper surface of the top mattress. This trench was then filled with gravel, which was worked down into the mattresses; stone was then added and the surface leveled off to an elevation of 1 foot above average flood tide. This work has been completed for a distance of 1,500 feet above the termination of the concrete blocks, while it has been commenced and both stone and gravel used over an additional length of 1,400 feet. Along the whole distance (2,900 feet) 2,678 cubic yards of gravel and 1,434 cubic yards of stone have been used.

On the river side of the concrete blocks at Station 112, 152 cubic yards of stone have been placed as a protection to their foundation; 36 cubic yards of macadam was also placed along the river side of the blocks at different points below Station 102; 76 cubic yards of marl (ballast material) were placed on the jetty near Station 70; and 70 cubic yards of gravel placed on the river side of the concrete blocks from Station 99 to 101.

The concrete blocks on this jetty show no serious displacement, as will be seen by reference to the tables concluding section 2, east jetty.

The sand reef west of the west jetty, shown on Chart No. 2, terminated 300 feet from the jetty, at Station 89, on January 19. This reef was connected with the jetty by a layer of loose willows, weighted with stone. Since then more willows and stone have been added, making the total quantity of material used 280 cords of willows and 92 cubic yards of stone. This connection was made in order to induce reef formation, and to obstruct a current on the sea side of the jetty, caused by water flowing over the jetty and through Kipp Dam.

Dam at Picayune Bayou.—The dam across this bayou, which is about three-fifths of mile above South Pass light-house, has been strengthened by the addition of 34 cords of willows.

Additional plant.—At times during the year when, on account of wind from a southerly or southeasterly direction, it was necessary to discontinue work on the jetties, the force was employed in distributing ballast which had been discharged from vessels, repairing wharves, walks, buildings, &c.

The wharf in front of the hotel has been entirely rebuilt and considerably enlarged. It is now 133 feet long and 38 feet wide. A new slaughter-house, 30 feet long and 25 feet wide, has been built on the west shore of the pass opposite East Point; also a

uilding 24 feet long and 20 feet wide on the wharf at East Point, to serve as quarters for the crew of the dredge-boat Bayley.

Repairs have been made to two dwelling-houses, and three houses, together with the hotel, have been repainted.

EXAMINATIONS AND SURVEYS.

During the year the work constituted under this head has been as follows:

Periodical surveys, to determine whether a channel of required dimensions was maintained through the jetties and at the head of South Pass; sediment and velocity observations; discharge observations, including the three passes; observations to determine the slope of South Pass; tidal observations; levels on concrete blocks, &c., together with more extended surveys, charts of which accompany this report, and office work required for the reduction and plotting of the whole.

At the Head of Passes.—I have extended the survey at this point further up stream than it has been extended since before the inauguration of the works of improvement, in order to ascertain the available channel depth from the main river into South Pass, and to make a comparison with a similar survey made in June, 1875, by the officers of the Coast Survey, and thus to note the changes produced by the works here after a lapse of five years. The chart of this survey is No. 4. Without entering into a long and tedious comparison to deter ine the areas and amounts of scour and fill, I will endeavor to present graphically the results of my determinations, so that at a glance an idea may be formed of the changes in the channels during the period under consideration.

On Chart No. 5 are given comparative cross-sections I J and G H, taken respectively 2?0 and 2,120 feet above Upper Dam; the extremities of the lines denoting the location of these sections are noted on Chart No. 4 by letters corresponding to those on the sections. Profiles of lines A B, C D, and E F, Chart No. 4, are also given on Chart No. 5. These sections and profiles are formed from Coast Survey soundings made June, 1875, and soundings made by United States engineers in June, 1880. From an inspection of them it will be seen that but little change has taken place in Southwest Pass; a shoaling is indicated below the mattress-sill in the location at which the profile is taken, though on the whole there has been a slight deepening below this sill. Northeast Pass shows a quite uniform deepening, while South Pass has greatly increased in depth. The deepening in South Pass above △ cluster, which was the shoalest portion on April 11, 1879, has been very rapid since that date, and also since December 2, 1879, as will be seen from an inspection of the profiles made from soundings taken on those dates. At the location where, on July 10, 1879, there was a channel 26 feet deep and 50 feet wide, there now exists (June 7, 1880) a 30-foot channel 400 feet wide.

On June 7 there was a channel from the main river into South Pass, having a depth of 2? feet and width 300 feet, with a central navigable depth of 28.8 feet.

The decrease in area of section I J is evident from inspection, while the influence of Upper Dam extends as far up as section G H, which has also decreased in area about ?,475 square feet during five years. The effect of Upper Dam on the improvement of the channel from the river into the pass may be traced to about 1,000 feet above it.

The survey of South Pass was continued to the head of Goat Island in order to ascertain the depth over the shoal area about 1¼ miles below the head of the pass. This survey is shown on Chart No. 4. The area in question has increased in depth so that on June 3 the least depth was 25.6 feet, where but 24 feet existed one year ago. This portion of the pass was alone surveyed at this time, as it contained the only shoal area in the pass liable to require deepening in order that a 26-foot channel may exist through the pass itself. A survey of the whole pass will be made when the river reaches its low stage, as such a survey only can be comparable with previous surveys, all of which were made during low river.

Discharge and slope observations.—When practicable, discharge observations in the three passes are made each month at the time when the moon is at its zero declination; it often occurs, however, that these days are too stormy for field work, and consequently these observations cannot be made so frequently as desired.

In connection with these observations, and at other times, though always at moon's zero declination, the slope of South Pass has been observed since April 12. Gauges were established every mile above South Pass light-house, and at Stations 22, 50, 80, and 110 on the jetties below, whose zeros correspond with the reading at average flood tide on the gauge at South Pass light-house, and were established by levels referred to this plane. Two series of readings were taken each day that observations were made, except on June 27, when only one series was taken. The results of these observations are given in full, both graphically and in tabular form, on Chart No. 5.

The following table gives the results of simultaneous discharge observations in the three passes since June, 1876:

Table giving results of simultaneous discharge observations.

Date.	Discharge in cubic feet per second.				Per cent. of total discharged by—			Stage of river at Carrollton, La.	Remarks.
	South Pass.	Southwest Pass.	Northeast Pass.	Total.	South Pass.	Southwest Pass.	Northeast Pass.		
1877.									
May 21	68, 387. 9	276, 280	292, 387	637, 054. 9	10. 7	43. 4	45. 9	10. 8	River stationary.
May 22	71, 254. 8	277, 450	292, 224. 5	640, 920. 3	11. 1	43. 3	45. 6	10. 9	Do.
Sept. 10	26, 688	125, 898	119, 669	272, 255	9. 8	46. 2	44. 0	0. 4	River rising.
1878.									
June 8	61, 561. 6	245, 501. 2	264, 822. 8	571, 885. 6	10. 8	42. 9	46. 3	10. 7	River rising slightly.
1879.									
Dec. 19	37, 893. 5	166, 894. 7	167, 822. 8	372, 611. 1	10. 2	44. 8	45. 0	3. 3	Do.
1880.									
Jan. 30	68, 181. 2	281, 792. 9	290, 699. 4	640, 673. 5	10. 6	44. 0	45. 4	11. 8	River stationary, top of rise.
Apr. 21	78, 410. 4	327, 916. 2	367, 199. 4	773, 526	10. 1	42. 4	47. 5	14. 2	Do.
Mean	....	....	....	....	10. 5	43. 8	45. 7	......	

The channel through the jetties.—In Appendix A are given copies of the certificates of United States Engineer Officers in charge of the inspection of the works of improvements, surveys, &c., during the year; they serve to show the condition of the channel during the greater portion of the year.

At a point 1,000 feet below East Point the 26-foot channel, which is now 200 feet wide, decreased in width about 60 feet since June 11, 1879; otherwise, the channel improvement has been very marked during the year, as will be seen by comparing Chart No. 2 with the chart of a corresponding number in the last annual report.

The least depth through the jetties at present is 31 feet, and the least width of the 30-foot channel is 40 feet; this width exists at points between 1,000 and 2,000 feet below East Point, and between the shoal areas beyond the ends of the jetties the least width of this channel is 70 feet.

Below a point 2,600 feet from East Point the least width of the 30-foot channel is 120 feet, except between the areas above referred to.

By an inspection of Chart No. 2, and a comparison with previous charts, the channel improvement below (Station 65 + 15) where the concrete work commences on the east jetty is very evident. This improvement is due to the building up of this jetty as indicated on Chart No. 2 (see note thereon), and thus confining a large volume of water which previously escaped over it.

The 30-foot channel near the end of the jetties, which was very narrow on May 22, and was maintained during the year by considerable dredging, has increased in width since that date, so that on July 1 it was 230 feet wide in its narrowest place. This rapid improvement was, no doubt, caused by the building of the last 140 feet of concrete blocks.

The depth of water east of the east jetty and west of the west jetty has increased below the sand reefs, while above them it has shoaled so that it is less than 1 foot at average flood tide.

The following table gives the minimum depths of the channel from East Point downwards, in lengths of 2,000 feet, at various dates, and serves to show the channel improvement:

Table showing depths through the jetties at various dates.

Date.	Distance in feet from East Point.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1875.						
June	22.5	18.7	16.7	10.2	9.7	9.2
1876.						
May	23.3	20.3	22.0	21.0	17.1	15.0
August	23.5	19.6	21.0	23.5	23.0	19.8
November	22.0	20.3	21.1	21.2	21.1	20.3
1877.						
March 16	24.1	21.1	23.2	22.0	21.2	20.5
April 2						21.3
April 22						20.5
May 10				22.1	21.4	19.5
May 24						17.8
June 28						18.0
July 3	24.9	24.0			23.5	
July 7				23.8		
July 8			26.0			
July 28						20.3
August 30						20.8
September 28						20.7
October 25		24.4				
October 31						21.0
November 3	26.3		28.5			
November 13				24.2		
December 1						21.3
December 7					23.0	
December 14						23.7
1878.						
January 1						23.0
February 2						22.8
March 4						23.2
March 13						20.5
March 24	26.0	25.9				
March 25			35.5			
March 26				25.4		
March 27					24.3	
April 3						23.0
May 9						23.2
May 23						22.3
June 3						22.2
June 19						22.0
July 2						21.9
December 2	28.4	26.4	35.7			
December 3				27.1	25.3	
December 6						23.0
December 28						23.0
1879.						
January 20						23.9
February 13						22.2
March 14						24.8
March 19	28.6	27.5	43.4			
March 24				27.0	27.0	
March 27						27.0
April 8						27.0
May 13						26.5
June 11	27.5					
June 12			47.7	29.2	29.2	
June 14						28.0
June 18		28.4				
July 8	30.5	30.7		31.0	30.7	30.5
August 15						29.0
September 3						31.0
October 7						30.5
November 6						30.5
December 3	31.0	31.0	48.3			
December 4				31.7	31.8	30.8
1880.						
January 2						31.1
February 4				31.8	32.0	
February 7	31.1					
February 10						30.9
March 5	31.6				31.6	30.6

Table showing depths through the jetties, &c.—Continued.

Date.	Distance in feet from East Point.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1880.						
April 6	....	....	....	31.3	31.0	30.5
May 3	33.0	....	....	32.1	33.3	31.4
June 29	31.0	32.5	....	....	....	....
June 30	....	....	47.8	31.4	35.1	....
July 6	....	....	....	....	....	32.0

Survey beyond the ends of the jetties.—The survey of the fan-shaped area, containing about 1¼ square miles, just seaward of the ends of the jetties was made in June, and is given on Chart No. 3. The soundings on this chart have been compared with those taken in July, 1879, and the scour or fill in each subdivision determined. The final result shows a mean scour over the whole area of 0.12 of a foot, a result so insignificant that we may well consider that there has been no change in this area during the year. The areas which show a shoaling are 2, 3, and 9, and all of those in the first tier nearest the ends of the jetties, viz, 13, 14, 15, 16, 17, 18, 19, 20, and 21.

Why there has been so little change over this area as compared with previous years may, I think, be accounted for by the building up of the east jetty, which confined the water and maintained the strong current created by the recent high river, and thus carried the sediment beyond the limits of the survey.

The following table gives the comparisons at different dates in detail of the quantities of water in 21 subdivisions of a fan-shaped area containing about 1¼ square miles immediately seaward of the ends of the jetties:

Number of division.	Area of subdivision in square feet.	Mean depth of subdivision, in feet. 1876.	1877.	1878.	1879.	1880.	Quantity of water overlying subdivision, in cubic yards. 1876.	1877.	1878.	1879.	1880.	Mean depth over whole area. Date.	Mean depth.
1	3, 359, 484	98. 0	86. 3	93. 18	89. 47	98. 87	12, 193, 680	10, 737, 893	11, 712, 156	11, 133, 335	11, 680, 428	June, 1876	60. 78
2	1, 951, 904	73. 0	76. 43	78. 12	71. 79	70. 06	5, 277, 360	5, 525, 320	5, 347, 511	5, 190, 423	5, 064, 106		
3	3, 203, 900	72. 524	73. 458	72. 38	69. 32	67. 91	8, 606, 200	8, 716, 392	8, 588, 820	8, 225, 954	8, 058, 639		
4	1, 771, 511	67. 455	67. 877	66. 40	61. 32	61. 92	4, 425, 860	4, 453, 514	4, 356, 630	4, 023, 625	4, 062, 665		
5	3, 195, 900	75. 342	73. 319	77. 60	74. 26	76. 47	8, 917, 980	8, 678, 488	9, 185, 253	8, 789, 980	9, 051, 617		
6	1, 951, 904	76. 724	81. 0	75. 34	74. 12	75. 57	5, 546, 570	5, 855, 700	5, 446, 535	5, 358, 410	5, 463, 379	June, 1877	60. 38
7	3, 146, 568	63. 63	62. 45	66. 38	62. 66	63. 57	7, 415, 403	7, 277, 886	7, 735, 899	7, 303, 062	7, 408, 419		
8	1, 177, 965	58. 40	59. 50	59. 74	58. 30	58. 62	2, 547, 905	2, 595, 882	2, 606, 356	2, 543, 532	2, 557, 449		
9	1, 911, 590	53. 7826	53. 892	56. 30	56. 58	52. 63	3, 807, 800	3, 815, 012	3, 986, 015	4, 005, 839	3, 726, 397		
10	1, 804, 280	47. 9336	48. 845	51. 83	47. 70	49. 12	3, 208, 170	3, 264, 076	3, 463, 548	3, 187, 621	3, 282, 921	July, 1878	62. 18
11	1, 910, 900	52. 4822	54. 075	56. 38	54. 54	54. 80	3, 714, 389	3, 827, 022	3, 990, 242	3, 860, 303	3, 878, 490		
12	1, 177, 965	50. 5625	52. 144	49. 97	51. 05	50. 75	2, 205, 950	2, 274, 950	2, 180, 110	2, 227, 400	2, 214, 138		
13	2, 664, 385	36. 803	38. 438	39. 57	40. 35	39. 67	3, 631, 752	3, 793, 096	3, 904, 805	3, 982, 775	3, 914, 672		
14	354, 931	31. 464	37. 02	35. 00	34. 78	33. 63	413, 612	486, 650	460, 095	456, 546	442, 086		
15	196, 900	35. 20	36. 325	40. 01	40. 26	35. 26	256, 699	264, 803	291, 766	293, 599	257, 159	July, 1879	59. 62
16	395, 320	33. 377	36. 471	35. 92	39. 01	37. 43	488, 689	533, 908	525, 922	571, 281	548, 133		
17	1, 658, 310	29. 2805	33. 256	32. 20	38. 16	32. 64	1, 798, 376	2, 042, 546	1, 977, 689	2, 036, 957	2, 004, 528		
18	390, 660	31. 444	32. 905	34. 00	35. 92	33. 07	454, 959	476, 003	491, 942	519, 838	478, 515		
19	195, 900	37. 0833	35. 1	39. 43	39. 47	37. 69	269, 090	254, 585	286, 086	286, 413	273, 469		
20	354, 931	35. 654	36, 85	37. 20	33. 47	32. 99	468, 690	484, 415	489, 016	440, 088	433, 686	June, 1880	59. 74
21	1, 942, 785	35. 012	31. 723	36. 50	30. 93	28. 17	2, 519, 288	2, 282, 681	2, 626, 357	2, 225, 567	2, 027, 548		
	*34, 717, 993	1, 095. 1537	1, 107. 378	1, 134. 40	....	....	78, 163, 422	77, 640, 825	79, 952, 753	76, 662, 548	76, 828, 444	....	....

*Square miles, 1.2453.

	Feet.
Mean fill over whole area from 1876 to 1877	0. 40
Mean scour over whole area from 1877 to 1878	1. 80
Mean fill over whole area from 1878 to 1879	2. 56
Mean scour over whole area from 1879 to 1880	0. 12
Mean fill over whole area from 1876 to 1880	1. 04

The movement of the various curves of equal depth have been determined by comparing those of July, 1879, with those of June, 1880, by measuring ordinates 50 feet apart at right angles with a common base; the mean ordinate of each curve on the two charts under consideration is obtained, and their difference is the advance or recession of the curve.

The following table gives the movement of curves from July, 1879, to June, 1880:

Designation of curve.	20′	30′	40′	50′	60′	70′	80′	90′	100′
Advanced seaward, in feet	95	18	223	......	96	......	......	......	......
Receded landward, in feet	......	......	......	33	......	26	7	65	139

I wish to acknowledge the service of Assistant Engineer Thomas L. Raymond, who has rendered valuable assistance during the year by close application to duty and the accuracy of his work. Mr. G. W. Lawes has also rendered valuable assistance, especially as a draughtsman.

Very respectfully, your obedient servant,

C. DONOVAN,
Assistant Engineer.

Capt. W. H. HEUER,
Corps of Engineers.

A.

The following are copies of certificates regarding the maintenance of channel at the mouth and head of South Pass of the Mississippi River, which were forwarded to the Hon. Secretary of War, through the Chief of Engineers, by the United States Engineer Officers in charge of the inspection of the works of improvement during the year.

CERTIFICATE OF THE UNITED STATES ENGINEER INSPECTING OFFICER OF THE FIRST QUARTER'S MAINTENANCE (IN 1879), BY JAMES B. EADS, OF THE 26 AND 30 FOOT CHANNELS AT THE MOUTH OF SOUTH PASS, MISSISSIPPI RIVER, DESIGNATED BY THE SEVERAL ACTS OF CONGRESS.

LAWRENCE, MASS., *November* 18, 1879.

I certify that between the dates of July 8, 1879, and October 30, 1879, Mr. James B. Eads maintained a channel for three months through the jetties at the mouth of South Pass, Mississippi River, 26 feet in depth and not less than 200 feet in width at the bottom, and having through it a central depth of 30 feet without regard to width.

During the aforesaid interval of time there were 22 days when a failure occurred in some part to maintain intact such a channel. This failure was on the 14th, 15th, 16th, and 17th of August, for the first period; from August 27 to September 11, inclusive, for the second period; and from October 23 to the 25th, two days, for the third period.

During the whole of the interval from July 8 to October 30 a freely navigable channel, having a greater depth than 26 feet, has been maintained at the head of South Pass.

The minimum condition to which the channel deteriorated from the 14th to the 17th of August, 1879, inclusive, and from the 27th of August to September 11, inclusive, and for the two days from October 23 to 25, are indicated in the following statements, applying to the mouth of South Pass.

August 14.—Opposite Station 20 the 30-foot channel was lacking for about 125 feet in length, and the least depth of water in the best channel was 28.5 feet.

August 15.—On the bar just inside the last wing-dam the 30-foot channel was lacking for about 90 feet in length, and 27.8 feet or 28 feet were indicated as present, although a sounding was lacking in the place needed to show a continuous line of that depth available for navigation.

In the same vicinity and at the same date the 26-foot channel was deficient in width for about 210 feet in length, its least width being about 155 feet.

August 27.—The 30-foot channel near Station 74 was lacking for about 130 feet in length; the least depth in the deepest channel was about 28.8 feet.

August 28.—At the same place the 30-foot channel had closed up, so that it was lacking for only 30 feet, and 29.5 feet was found in the deficient interval.

August 28.—Just above the upper wing-dam, near Station 19, the 30-foot channel was lacking for about 500 feet in length, and 28.7 feet was found as the least depth in the intervals for the deepest channel.

August 28.—Between near Stations 10 and 20, for 800 or 900 feet in length, the 26-foot channel was less than 200 feet wide, its least width being about 150 feet.

September 4.—Near Station 10 the 30-foot channel was lacking for about 750 feet, and about 29 feet was the greatest depth found.

October 23.—The 26-foot channel was deficient in width opposite Station 28 for about 200 feet in length, its least width being about 180 feet.

I certify that the above statements present truly the results of official surveys made at South Pass, Mississippi River.

M. R. BROWN,
Captain of Engineers, U. S. A.

CERTIFICATE OF THE UNITED STATES ENGINEER INSPECTING OFFICER OF THE SECOND QUARTER'S MAINTENANCE (IN 1879 AND 1880), BY JAMES B. EADS, OF THE 26 AND 30 FOOT CHANNELS AT THE MOUTH OF SOUTH PASS, MISSISSIPPI RIVER, AS DESIGNATED BY THE SEVERAL ACTS OF CONGRESS AUTHORIZING AND PERTAINING TO THIS IMPROVEMENT.

LAWRENCE, MASS., *February* 16, 1880.

I certify that, between the dates October 30, 1879, and February 15, 1880, both dates inclusive, Mr. James B. Eads maintained a channel for three months "through the jetties" at the mouth of South Pass, Mississippi River, "26 feet in depth and not less than 200 feet in width at the bottom," and having through it "a central depth of 30 feet without regard to width."

During the aforesaid interval of time there were seventeen days when a failure occurred in some part to maintain such a channel.

This failure was from November 3 to the 15th, both dates inclusive, according to official surveys made on November 3 and again on November 16. But on November 10 the channel was *claimed* as restored, although stormy weather prevented the verification of this claim until November 16.

Failure also occurred in some part and degree from the 21st to the 24th of November, both dates inclusive.

During the whole of the interval from October 30, 1879, to February 15, 1880, both dates inclusive, a freely navigable channel, having a greater depth than 26 feet, has been maintained at the head of South Pass.

The minimum conditions to which the channel deteriorated from the 3d to the 15th of November, inclusive, and from the 21st to the 24th of November, inclusive, are indicated in the following statement applying to the mouth of South Pass:

November 3, 1879, within but near the ends of the jetties, the 30-foot channel was lacking for about 300 feet in length and the least depth of water in the best channel through the shoal portion was 28.8 feet. The 30-foot channel was restored in this locality after 6¼ hours of dredging, according to a survey on November 4. In the same vicinity, but nearer the ends of the jetties, the 26-foot channel was, on November 3, found to be deficient in width for a length of 250 feet; instead of having the required width of 200 feet, the minimum width was 158 feet. The dredge-boat worked on this shoaling until November 10, and it was then reported for survey by Mr. Eads's representative as restored to the normal width; but on account of stormy weather a survey could not be made until November 16, and then the above designated channel was restored to its proper width, the dredge-boat having worked in restoring *it* 18¼ hours.

November 6, between Stations 70 and 110, the 26-foot channel was deficient in width in five places, aggregating about 1,200 feet in length. The least width was 165 feet. Portions on these deficient stretches were successively restored to the proper depth, according to surveys made November 7, 10, and 16, after dredging had been prosecuted 42 hours.

November 6 the 30-foot channel was interrupted in three places, aggregating 160 feet in length, and the least depth in any of these shoal portions, in the deepest channel found, was 29.5 feet.

The deficiencies were easily removed while dredging to restore the deterioration in the width of the 26-foot channel, just above noted.

November 21, between stations 70 and 100, the 26-foot channel was deficient in width in three places, aggregating 335 feet in length, and the least width here was 163 feet

Also, on November 21, between Stations 75 and 101, the 30-foot channel was interrupted in four places, aggregating in length about 420 feet, and the least depth where the deficiency existed, in the deepest channel, was 29.1 feet.

These deficiencies in the 26 and 30 feet channels were found all restored by the survey ending November 25, after 37¼ hours of dredging, which included the time spent in dredging still another area where, on November 24, the 30-foot channel was wanting in two places, aggregating about 125 feet in length, and where the least depth in the deepest water was 28.8 feet.

Between November 3, when the first deficiency in the second quarter's maintenance

was discovered, and November 10, when Mr. Eads's representative reported this deficiency removed, the dredge Bayley worked 61¾ hours, on seven days, and during the stormy weather which prevented a survey, from November 10 to November 16, the dredge worked 24 hours in all, on the 13th, 14th, 15th, and 16th of November.

Altogether the dredge Bayley worked in maintaining and restoring the channel 142¾ hours in November, 53 hours in December, 4 hours in January, and up to February 10, inclusive, 23 hours in this month of February.

Accompanying this certificate are charts which present the condition of the channel at the times and in those places where a deficiency existed, marked No. 2, No. 3, No. 4, No. 5, and No. 6, respectively.

I certify that the above statements present truly the results of official surveys made at South Pass, Mississippi River.

M. R. BROWN,
Captain Engineers,
U. S. Engineer Inspector of South Pass Jetties Improvement.

UNITED STATES INSPECTING OFFICER'S CERTIFICATE FOR MAINTENANCE OF CHANNEL AT SOUTH PASS OF THE MISSISSIPPI RIVER, AS DESIGNATED BY AN ACT OF CONGRESS APPROVED MARCH 3, 1879.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., May 9, 1880.

I certify that between the dates of February 10, 1880, and May 9, 1880, both dates inclusive, Mr. James B. Eads maintained "a channel through the jetties" at the mouth of South Pass of the Mississippi River "twenty-six feet in depth, not less than two hundred feet in width at the bottom, and having through it a central depth of thirty feet without regard to width."

W. H. HEUER,
Captain Engineers.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., May 14, 1880.

I certify that between the dates of February 10, 1880, and May 9, 1880, both dates inclusive, a navigable channel, having a greater depth than 26 feet at average flood tide, was maintained at the head of South Pass, Mississippi River.

W. H. HEUER,
Captain of Engineers.

FINANCIAL STATEMENT.

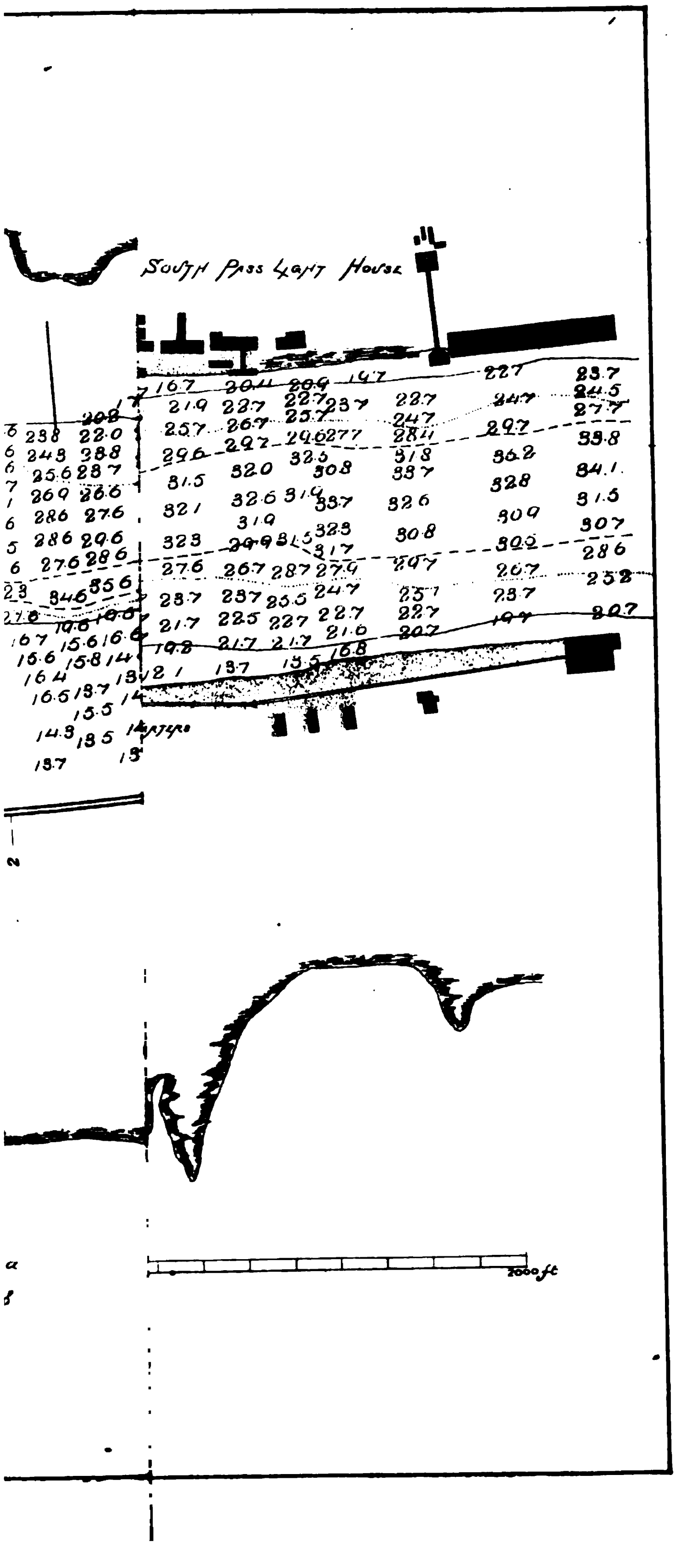
Amount available from appropriations for examinations and surveys at South Pass of the Mississippi River June 18, 1880....	$7,528 38	
Amount appropriated by act approved June 14, 1880............	20,000 00	
		$27,528 38
Amount expended from June 18 to June 30, 1880........................		2,372 16
Amount available July 1, 1880		25,156 22
Amount available July 1, 1879	28,825 37	
Amount appropriated by act of June 14, 1880	20,000 00	
		48,825 37
Amount expended during the fiscal year ending June 30, 1880, as follows: As per accounts of Capt. M. R. Brown from July 1, 1879, to April 9, 1880	17,947 68	
As per accounts of Capt. D. W. Lockwood from April 9, 1880, to June 18, 1880..	2,792 24	
As per accounts of Capt. W. H. Heuer from June 18 to June 30, 1880..	2,372 16	
Amount allotted "Mr. James Eveleth, Agent Engineer Department," Washington, D. C., "to pay clerk employed by direction of the honorable Secretary of War, at the War Department, to June 30, 1880, at the rate of $1,000 per annum. (See letter of December 17, 1879, from Chief of Engineers).......	557 07	
		23,669 15
Amount available July 1, 1880..		25,156 22

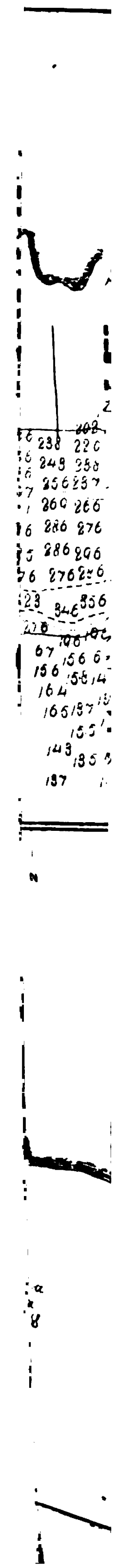
ESTIMATE OF FUNDS REQUIRED FOR EXAMINATIONS AND SURVEYS AT SOUTH PASS OF THE MISSISSIPPI RIVER FOR THE FISCAL YEAR ENDING JUNE 30, 1882.

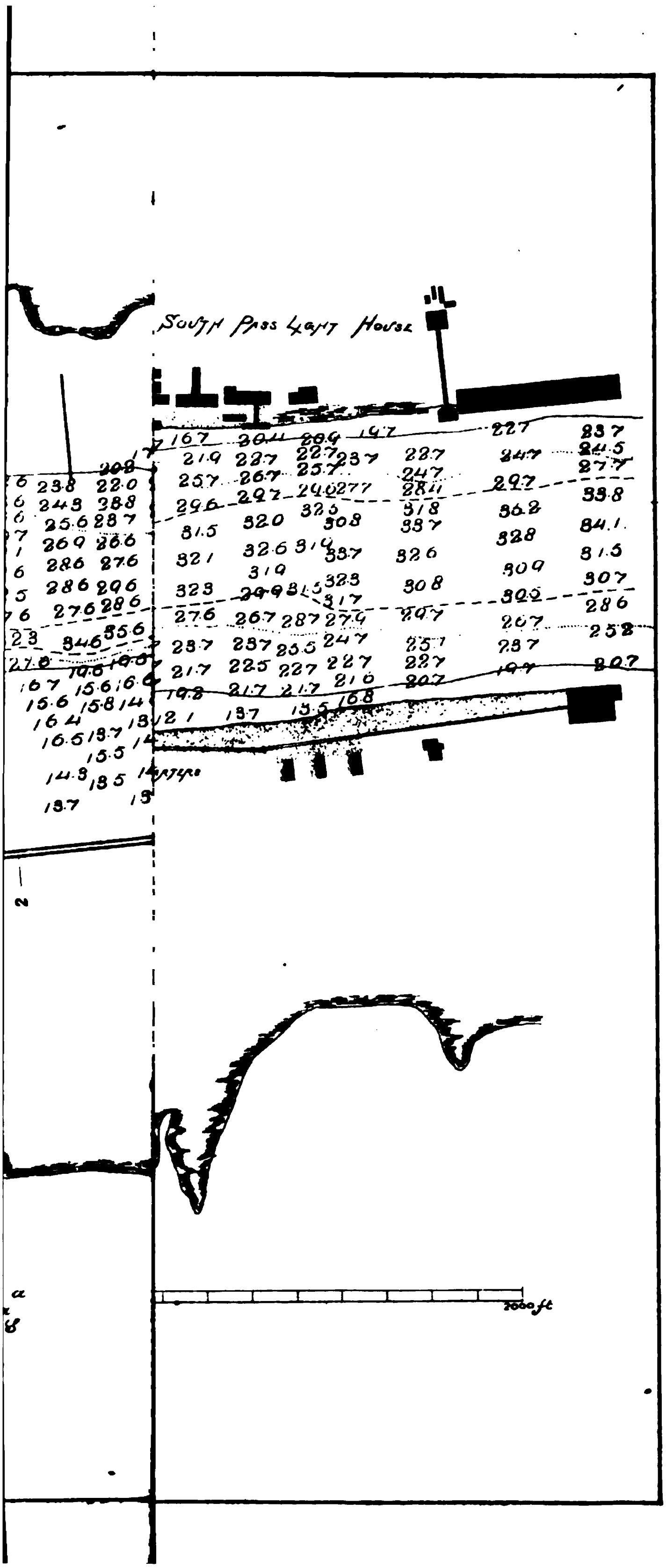
Two assistant engineers	$4,000 00
Two steam engineers	2,400 00
Ten seamen	7,800 00
Rent of officers' quarters	432 00
Rent of assistant engineers' quarters	240 00
Mileage and traveling expenses	500 00
Fuel for steam launches	1,000 00
Repairs to launches and boats	1,500 00
Materials and supplies for launches	500 00
Stationery and supplies for office	400 00
Freight, telegrams, express charges, &c.,	300 00
Contingencies	1,000 00
Total	20,072 00

W. H. HEUER,
Captain of Engineers, U. S. A.

238 22
245 23
256 25
260 26
280 27
286 29
276 2
346
167 156
156 53
164
165 57
15
143 15
137


South Pass Light House
2000 ft

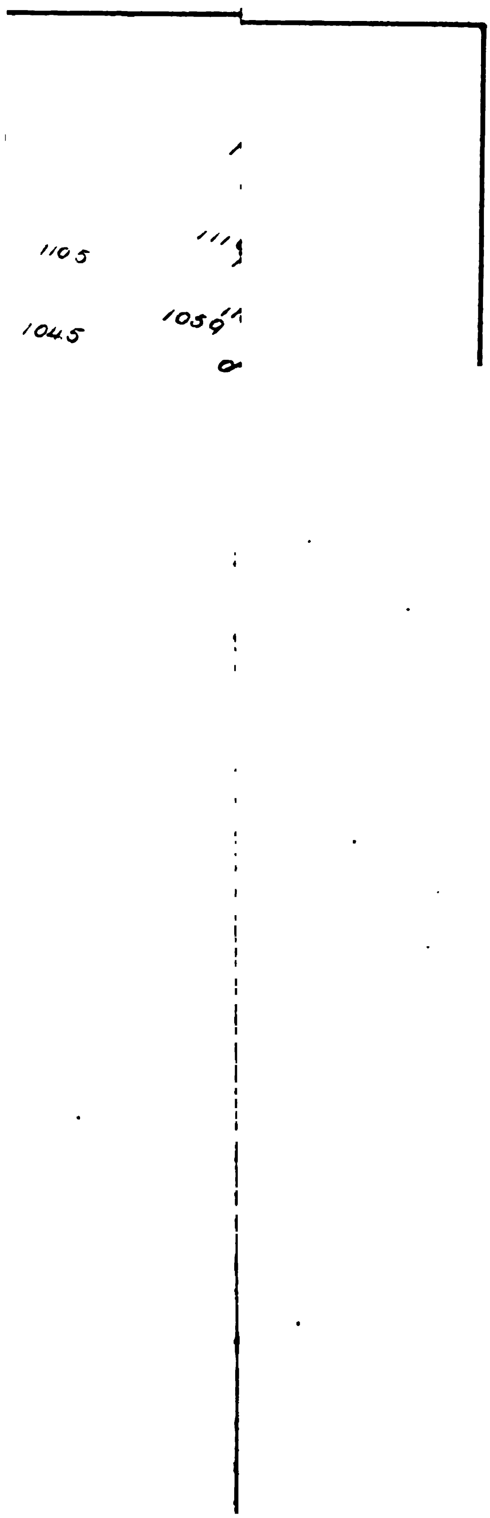



South Pass Light House
2000 ft

0

1105

1045


1105
1045
1059

APPENDIX M.

IMPROVEMENT OF THE HARBOR OF NEW ORLEANS; OF PEARL RIVER, MISSISSIPPI; OF TANGIPAHOA, AMITE, AND VERMILLION RIVERS, AND BAYOUS TERREBONNE, TECHE, COURTABLEAU, AND LAFOURCHE, LOUISIANA; AND OF SABINE PASS, TEXAS.

REPORT OF MAJOR C. W. HOWELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 20, 1880.

GENERAL: I have the honor to forward herewith the annual report for the fiscal year ending June 30, 1880, of the various works of river and harbor improvements under my charge.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

M 1.

IMPROVEMENT OF HARBOR AT NEW ORLEANS, LOUISIANA.

HISTORY.

This work originated from a survey made in the winter of 1877 and 1878, under the direction of a Board of Engineers, convened at the request of the city authorities of New Orleans, to consider plans for the protection of the harbor front of New Orleans from the effects of caving banks of the Mississippi along that front. (See Report of the Chief of Engineers, 1878, volume I, Appendix J 10.)

The United States assumed charge of the work in 1878, and an appropriation of $50,000 was made for its commencement.

Under this appropriation work was begun and continued by hire of labor and purchase in open market until the appropriation was exhausted. (See Report of Chief of Engineers, 1879, Appendix K 1, and this report.)

By act of Congress approved March 3, 1879, further appropriation was made to the amount of $60,000, and under this the work was put out at contract. (See this report.)

By act of Congress approved June 14, 1880, appropriation of $75,000 was made for continuance of improvement, and this it is proposed to offer at contract. (See this report.)

The work for the fiscal year ending June 30, 1880, has been such as indicated in my report for 1879, viz:

The balance of the appropriation of 1878 ($14,931.39) has been expended in continuance of the work by hire of labor and purchase in open market, and the appropriation of 1879 has been put out at contract.

WORK UNDER BALANCE OF APPROPRIATION OF 1878.

In regard to this I submit the following extracts from my monthly reports:

July.—A barge load of canes was received July 14, and the work of weaving mats was resumed July 15. Eleven mats, 200 by 26 feet, were placed, matting 30,800 superficial feet of bank; 80 piles were driven in line between the wharf at the head of Marigny street and lower side of wharf at Post No. 24, between Spain and Enghien streets, third district.

Twenty-four piles were pulled at different points along the line of the piles driven.

July 26.—The work of weaving and sinking mats was again suspended on account of failure of contractor in supplying cane. * * *

August.—During the month 22 mats, 200 by 26 feet, were placed, matting 61,600 superficial feet of the river's bank, or 308 running feet frontage; 211 sections of mat were woven, and 3,987 bags for ballast were filled with sand. Seven days were lost by failure of contractor to keep a supply of cane at the works, and three days lost by stormy weather.

August 22.—The ways barge was sunk during a severe storm.

* * * * * * *

September.—Fourteen mats, 200 by 26 feet, and 1 mat, 175 by 26 feet, were placed, matting 41,650 superficial feet of the river bank. September 1 a severe storm commenced, increasing to a hurricane, resulting in the following loss to the work, notwithstanding every effort was made to save the property:

One ways barge broke up and went to pieces, valued at	$475 00
One sand barge sunk, valued at	75 00
Sixty tons of sand lost on sand barge	33 00
Damage to pile-driver, loss of sand bags filled, say	50 00
Total damage (estimated)	633 00

Twelve piles were driven during the month. Owing to the losses above reported the work of making and placing mats was suspended after September 1 until the 22d, when, a barge having been purchased and fitted up as a ways barge, the work of placing mats was resumed and continued during the remainder of the month * * *

October.—The work of manufacturing and placing mats was continued to October 15, when operations were suspended on account of exhaustion of the appropriation of June 18, 1878. Twenty-seven mats, 200 by 26 feet, were placed, matting 75,600 superficial feet of the river bank. * * *

The principal items in the foregoing extracts sum up as follows, viz:

Number of carpets laid	74
Running feet of front covered	1,116
Square feet of river bed covered (=16,628 square yards)	149,650

If it had been possible to have laid the carpets with the same regularity as they could have been laid above water, they would have covered 207,200 square feet = 23,022 square yards.

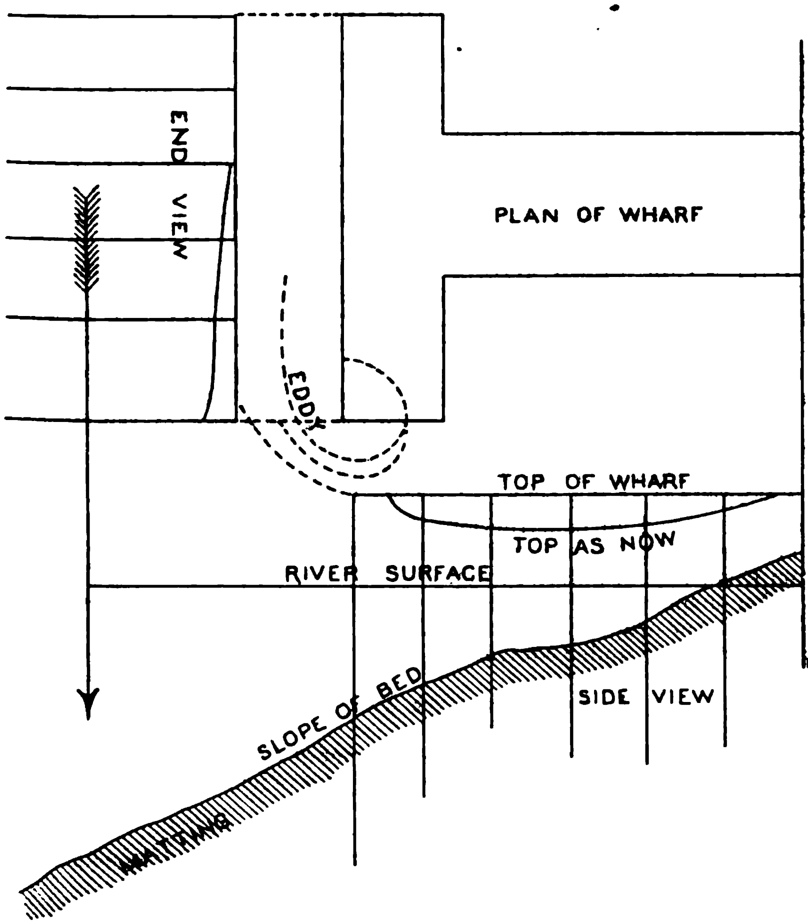
The loss, therefore, due to the variable currents and eddies that disturb the laying of the mats, is about 25 per cent.

Making an estimate in the manner of report of 1879, and taking the balance of appropriation of 1878 ($14,931.39) for our purpose, the following results, viz:

Cost per square yard covered	$0.89+
Cost per running foot of front	13.38+

The figures go toward confirming the opinion expressed in my report of 1879, viz: That experience would result in a great reduction of cost—a reduction to $10 or less per running foot.

Estimate based on the laying of the last 9 mats put down shows a further reduction, viz, 83 cents per square yard and $8.68 per running foot; but these mats were laid under favoring circumstances, and the figures cannot be taken as a sound basis for estimate of the work done and yet to be done on that portion of the harbor front obstructed by shipping and caved-in wharves. It is, however, no doubt, large for unobstructed portions of the harbor front.



In prosecuting the work above reported much annoyance and delay was caused by the shipping in the harbor, and it was found necessary to move from point to point on the line, leaving breaks to be filled in as the shipping was removed from their front. This was done so as to inconvenience as little as possible all parties concerned, and the line of mats was finally made continuous with exception of one gap left open on account of construction of a ferry slip at the head of Elysian Fields street. It is now observed that the portion of the harbor front above

this break has stood well during the year, while the two wharves below the break (which were covered by the matting) have given way.

This may suggest that continuity of the line of protection should be preserved from its point of commencement at the foot of the batture to the lowest point in the river bend needing protection.

It is further suggested, inasmuch as the two wharves referred to have been heavily loaded with merchandise, since the placing of the protection work in front of them, that the weight of this merchandise has had much to do with the giving way of the wharves.

This is indicated by the manner in which the wharves have gone down, as illustrated by the diagram on page 1147.

It is the center of the wharves (where the merchandise is generally piled) that gives down, and the lower corner of the T head, about which there is usually an eddy.

If the wharves were more substantially built with piling extending to a suitable depth, and if the piling of heavy merchandise on top of them should be prevented, the matting in front will protect them from the action of the river currents, and I have no doubt that they would stand securely.

With a view toward getting full information regarding the causes affecting the stability of wharves, I had a record kept, in the usual form, of all piles driven during the year. This record has not yet been carefully studied, but a brief examination shows great irregularity in the character of the holding ground afforded the piles. This matter will be made the subject of further study during the present year.

The river is yet at too high a stage for examination of the work now down to ascertain its condition.

It was suggested last year that the shrimps (which are known to eat the oakum out of the seams of vessels lying in port) might attack the spun-yarn used in construction of the mats. Some experiments were therefore made, serving to indicate that there is nothing to be feared from this cause of deterioration.

After suspension of work in October, the record of the year is only one of the care of property left on hand, and the completion of arrangements for continuance under contract.

CONTINUANCE BY CONTRACT.

Appropriation of $60,000 was made by act of Congress approved March 3, 1879. Under date of April 5, 1879, I was officially notified of appropriation and directed to submit project.

Project was submitted under date of April 12.

Under date of September 6, I submitted for approval specifications, &c., and requested authority to publish.

September 17, I published advertisement asking for proposals.

October 20, bids were opened.

The following is an abstract:

Abstract of bids received for improving harbor at New Orleans, La.

No.	Bidders.	Residence.	Guarantors.	For covering per square yard of river bed.	Time of commencing work.	Remarks.
1	D. W. Williams	New Orleans, La.		$2 10	July 1, 1880, on or before.	Proposal signed by guarantors as well as bidder; proposal not witnessed; guarantee not signed or witnessed; no certificate to guarantors.
2	John Roy	do	William Wells, Henry Cassidy.	65	On or before July 1, 1880.	
3	W. H. Bell	do	William Henry, E. H. Burton.	77½	20 days after signing contract.	No witness to proposal "myself" left out in proposal; no witness to guarantee and no date.
4	Greenleaf Andrews, president New Orleans Wrecking Company, Andrew Brady, C. I. Fayssoux.	do	Andrew Brady, C. I. Fayssoux.	1 35	November 20, 1879.	Guarantee have signed proposals; since ascertained that Brady & Fayssoux intended to sign as guarantors only.
5	A. L. Gervin, and C. W. Sargent.	do	A. L. Gervin, C. W. Sargent.	48	November 1, 1879.	No seal to proposals; residence of Sargent not giv.n on proposals; county not changed to parish; residence differs on guarantee; no seals to guarantee. (See par. 3722 R. S.)
6	E. P. Doherty	do	J. S. Parsons, J. L. Lalaurie.	79	November 1, 1879.	Received late; guarantee signed but not filled out; no seals on one; residence on bid not stated; "myself" left out; no witness; no seal on one proposal.

By direction of the Chief of Engineers the bid of A. L. Gervin and C. W. Sargent was accepted and due notice given to these parties to present themselves and bondsmen to enter into contract. These bidders failing (Mr. Sargent refusing to enter into contract), authority was given to contract with John Roy (the next lowest bidder).

Accordingly, on the 26th of December, articles of agreement were entered into with Mr. Roy and in due time approved.

The body of the agreement is as follows, viz:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Charles W. Howell, for and in behalf of the United States of America, and the said John Roy, for himself, his heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz: To manufacture, furnish, and place an artificial covering of cane mats over the sloping portion of the river-front of the third district of New Orleans, La., in a similar manner and in continuation of the same work as has been done heretofore under the direction of the said party of the first part, and as set forth in said specifications and proposals herewith attached.

It is further agreed between the contracting parties aforesaid that the said party of the second part may place his guide-piles 7 feet apart, from center to center, instead of 6 feet apart, as provided for in said specifications, for the reason that 14 feet clear width of each mat is calculated to cover that portion of the line measured along the guide-piles.

It is further agreed between the said contracting parties that the said party of the second part shall have all his plant and material, and have made his arrangements to commence and shall commence the laying of mats on or before the date at which the Mississippi River, after the flood of 1879 and 1880, shall have fallen to a stage represented on the Carrollton gauge as a 7-foot stage.

For and in consideration of the said party of the second part faithfully complying with his agreement, the said party of the first part agrees to pay to the said party of the second part, or his heirs, executors, and administrators, the sum of 65 cents per square yard for all such sloping portion of the river bank as the said mats may cover to the satisfaction of the said party of the first part, less, each payment, the percentage specified hereinafter, which is to be held until satisfactory completion of contract.

I am informed that the contractor has his arrangements made to commence as per agreement, which will probably be some time in July, 1880.

Under the appropriation of June 10, 1880—$75,000—it is proposed to commence work in the Carrollton Bend (section No. 1 of this work), beginning at the foot of the batture in this bend, and making the work continuous down stream. The work to be let out at contract. The specifications to be similar to those of present contract.

The reasons are these:

1. The present contract will probably cover all of section No. 2.

2. Even if it does not, it would be troublesome to have two contractors working on section No. 2 at the same time.

3. The section No. 1 has been considered in a dangerous condition for the past few years.

4. The Board of Engineers placed it next in importance to section No. 2.

5. The experience to be gained on it will be of greater value, in consideration of plans for bank protection and general river improvement, than can be given on any other part of the work about the harbor of New Orleans.

The following statistics regarding the commerce of the port of New Orleans for the year ending June 30, 1880, have been kindly furnished by the collector of the port, General A. S. Badger:

Steam vessels entered	451
Sailing vessels entered	725
Total	1,176

Tonnage of steam vessels....tons..	795,450
Tonnage of sailing vessels....do...	402,979
Total	1,198,429
Steam vessels cleared	575
Sailing vessels cleared	722
Total	1,297
Tonnage of steam vessels....tons..	810,915
Tonnage of sailing vessels....do...	397,456
Total	1,208,371

IMPORTS.

Specie	$230,901 00
Free commodities	4,625,596 00
Dutiable	5,723,419 00
Total	10,579,916 00

EXPORTS.

Domestic commodities	$9,238,757 00
Foreign commodities	176,443 00
Total	9,415,200 00
Total amount collected on imports	2,080,598 57

The work is located in the collection district of New Orleans, and the nearest light-house on the river is at the head of the passes.

Its degree of permanence is yet a matter of doubt.

To continue the work of improvement under the present project an additional appropriation of $200,000 is recommended for the fiscal year ending June 30, 1882.

Original estimated cost	$476,000 00
Amount appropriated	185,000 00
Amount expended	51,911 23

Money statement.

July 1, 1879, amount available	$74,931 39	
Amount appropriated by act approved June 14, 1880	75,000 00	
		$149,931 39
July 1, 1880, amount expended during fiscal year	16,604 27	
July 1, 1880, outstanding liabilities	238 35	
		16,842 62
July 1, 1880, amount available		133,088 77
Amount (estimated) required for completion of existing project		291,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		200,000 00

M 2.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, FROM JACKSON TO CARTHAGE.

This work originated from an examination which was provided for by Congress in the river and harbor act of 1878, report of which survey will be found in the Annual Report of the Chief of Engineers for 1879, Appendix K 2.

In the river and harbor act approved March 3, 1879, appropriation of $6,000 was made for commencing the work between Jackson and Carthage, and (see report above cited) it was proposed to expend this amount (as far as it would go) by contract in removing obstructions that it was estimated would cost $21,000 to remove.

In preparing specifications for the work so as to trim the latter to suit the amount appropriated, and yet be of as much benefit to navigation as possible, it was decided to limit the work to those obstructions that would most embarrass navigation at a stage 5 feet above the low-water stage of the river.

After approval of these specifications, and after the work had been duly advertised under them, bids were received and opened on October 20.

The following is an abstract of the bids received:

Abstract of bids received for improving Pearl River, Mississippi, from Jackson to Carthage.

Number.	Bidders.	Residence.	Guarantors.	For removal of obstructions as specified.	Time of commencing work.	Remarks.
1	Jonas S. Hamilton	Jackson, Miss		To P, inclusive, and one mile additional, from Jackson up.		Second guarantors not filled up. Three accompanying papers.
	W. H. Gibbs	do	W. H. H. Green			
	J. A. Hoskins	Brookhaven, Miss	E. Bloom	$5, 500		
	J. S. Hamilton & Co					
2	George Pearson	New Orleans, La	W. M. Robinson, A. H. Delmos.	To I, inclusive		
3	H. E. Glasscock	Madison, Miss		To P, inclusive		Proposals to do further work than specified; note on proposals; names of guarantors not legible; two accompanying papers.
4						Received late. Proposals not filled out or signed. Guarantee only partly filled out on one, only signed on other. Bidder put in guaranty as one of the guarantors. Parsons signs guarantee but is not named in heading.

J. S. Hamilton & Co. being the lowest responsible bidders the contract was awarded them, and articles of agreement duly entered into under date of November 20, 1879, and approved under date of December 1, 1879.

The following is the body of the agreement:

This agreement witnesseth that, in conformity with the advertisement and specifications hereunto attached, and which form a part of this contract, the said Charles W. Howell, for and in behalf of the United States of America, and the said J. S. Hamilton & Co., for themselves, their heirs, executors, and administrators, have mutually agreed, and by these presents do mutually covenant and agree, to and with each other, as follows, viz:

To perform the work of removing obstructions to navigation in Pearl River between Jackson, Mississippi, and Carthage, Mississippi, marked A to P, inclusive, in conformity with their proposal, copy attached, and as set forth in said advertisement and specifications.

At the time agreement was entered into the river was at too high a stage for commencement of work. Under date of March 11, 1880, the contractors informed me that they were ready to commence, and called for an inspector to aid them in recognizing the work provided for in their agreement. An inspector (the assistant who made the examination) was at once dispatched to perform the duty (provided for in agreement).

The duty was performed and duly reported to me.

Since that I have been informed by the contractors of progress in their work to this effect: That they have been engaged on such work required of them as could be done, the stage of the river considered, viz, the cutting of trees on bank, and that they would attend to the other work as the river fell, so as to permit them to work to advantage.

Under the agreement no further inspection will be required until the contractors claim that they have fulfilled their part of the agreement.

In the river and harbor act approved June 14, 1880, there was further provision made for this work to the amount of $7,500.

The following project for expenditure of this amount has been submitted, viz:

PROJECT.

It is proposed to continue the improvement by the removal of all obstructions (not covered by present contract) to a 5-foot low-water navigation from the bridge at Jackson to the highest point on the stream above that the appropriation will cover, and also to let out this work at contract.

Specifications drawn in accordance with the above project have also been submitted.

The work is located in the State of Mississippi, and the nearest light-house is on the Rigolets, opposite mouth of West Pearl River.

The work is not considered permanent because it appears quite certain that the channel opened will gradually fill in places with drift, &c.

To complete the improvement of this river under the present project an additional appropriation of $7,500 is recommended for the fiscal year ending June 30, 1882.

Original estimated cost	$21,000 00
Amount appropriated	13,500 00
Amount expended	213 03

Money statement.

July 1, 1879, amount available	$6,000 00	
Amount appropriated by act approved June 14, 1880	7,500 00	
		$13,500 00
July 1, 1880, amount expended during fiscal year		213 03
July 1, 1880, amount available		13,286 97
Amount (estimated) required for completion of existing project		7,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		7,500 00

M 3.

IMPROVEMENT OF PEARL RIVER, BELOW JACKSON, MISSISSIPPI.

This work originated in an examination authorized by act of Congress approved June 18, 1878, a report of which, together with plan and estimate, was published in Report of the Chief of Engineers for 1879, Appendix K 2.

By act of Congress approved June 14, 1880, the sum of $30,000 was appropriated for its commencement.

It is proposed to commence the work of improvement at Jackson and continue it down stream, so far as the amount appropriated will permit, by removing from the banks all overhanging trees and disposing of them in such manner that they may not again become obstructions to navigation. Also to clear a passage-way 100 feet wide through the fish-traps situated a short distance below Jackson, and to remove from the bed of the river all trees, logs, and snags found in it to a depth of at least 5 feet below low-water mark, or, where such depth of water does not exist, to the bottom of the river, said trees, logs, and snags to be placed in cut-offs or run-out bayous, or where cut-offs or run-out bayous are not available, to place them on the banks and burn them or otherwise dispose of them so that they shall not again become obstructions to navigation.

The work to be done by contract and award to be based on the number of miles proposed to be improved for the amount of money available.

The original estimate for this work was $95,940, or $65,940 more than has been appropriated, and it is therefore recommended, for the continuance of the work under the present project, that an additional appropriation of $65,940 be made for the fiscal year ending June 30, 1882.

The commercial importance of this work was indicated in the report of examination.

The work is not considered of a permanent character, as obstructions, caused by trees falling into the river, drift-logs, and snags are liable to reform at any time.

The work is located in the collection district of New Orleans, and the nearest light-house is on the Rigolets, opposite mouth of West Pearl River.

Original estimated cost	$95,940
Amount appropriated	30,000

Money statement.

Amount appropriated by act approved June 14, 1880	$30,000 00
July 1, 1880, amount available	30,000 00
Amount (estimated) required for completion of existing project	65,940 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	65,940 00

It is proposed to have the work done by contract, proposals being invited in the usual way and award based on the amount for which the bidder proposes to clear the river, as indicated, from the railroad bridge to its mouth.

The original estimate for the work was $9,900, or $4,900 more than the amount appropriated, and it is therefore recommended that an additional appropriation of $4,900 be made for the fiscal year ending June 30, 1882.

The commercial importance of the stream was set forth in report of the survey. The work is not considered permanent, as the obstructions to navigation, caused by drift-logs, snags, &c., may be replaced by others of a similar character from caving banks and other causes.

The work is located in the collection district of New Orleans, and the nearest light-house is at the entrance of Atchafalaya Bay.

Original estimated cost	$9,900
Amount appropriated	5,000

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00
Amount (estimated) required for completion of existing project	4,900 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	4,900 00

M 7.

IMPROVEMENT OF BAYOU TERREBONNE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $10,000 was made for its commencement.

It is proposed to expend this sum in obtaining a 4-foot navigable channel down the bayou from Houma. To do this it will be necessary to clear away the overhanging willows and bushes on the right bank of the bayou for a distance of 20 miles below Houma and to dredge the shoal spots that exist at intervals for a distance of 6 miles below that place.

The work to be done by contract.

The work is not considered permanent, as the shoals below Houma are apt to reform with each high-water.

The original estimate for this work was $18,800, or $8,800 more than the amount appropriated. A further appropriation of $8,800 for the fiscal year ending June 30, 1882, is therefore recommended to continue the work of improvement and maintaining a navigable channel 4 feet in depth from Houma down.

The commercial importance of the bayou was indicated in the report of the examination.

The work is located in the collection district of New Orleans. The nearest light-house is near the east end of Timbalier Island.

Original estimated cost	$18,800
Amount appropriated	10,000

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	8,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	8,800 00

M 8.

IMPROVEMENT OF BAYOU TECHE, FROM SAINT MARTINSVILLE TO PORT BARRE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $6,000 was made for its commencement.

It is proposed to expend this money in the work of improvement by removing from the bank all trees to a distance of 50 feet from the middle of the bayou; also to remove all trees, logs, snags, wrecks, and other obstructions from the bed of the bayou to 5 feet below low-water surface, or where such depth of water does not exist to the bottom of the bayou, and placing them on the banks above high-water or burning them, so that they shall not again become obstructions to navigation.

From Leonville to Port Barre, 13 miles, there has not been sufficient water for navigation within the memory of the oldest inhabitants, except during the extreme high-water of 1874. At the time of the examination, the low-water surface at Leonville was 4½ feet above that in the Courtableau, while 4 miles from Port Barre *the bottom* of the channel was 6 feet above low-water in the Courtableau.

For these reasons it is not deemed advisable at present to expend any of the appropriation for this year in improving the bayou above Leonville.

The work to be done by contract.

The original estimate, which was for improving the bayou from New Iberia to Leonville, provided for 3 needle-dams and locks, by which good navigation would be secured during the year, at high-water the dams being removed; and it is recommended that an appropriation of $50,690 be made for the fiscal year ending June 30, 1882, to complete the improvement.

The small bars found in this bayou are caused by draining ditches, and some means should be adopted to stop this and have the drainage ditches run into the swamps instead.

The work may be considered of a permanent character, in the ordinary acceptation of the term permanent as applied to works of this kind, if with needle-dams and locks; otherwise not, as the obstructions, caused by trees, logs, and snags, are liable to reform.

The commercial importance of the work is set forth in the report of examination.

The work is located in the collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Original estimated cost	$50,690
Amount appropriated	6,000

Money statement.

Amount appropriated by act approved June 14, 1880	$6,000 00
July 1, 1880, amount available	6,000 00
Amount (estimated) required for completion of existing project	50,690 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	50,690 00

It is proposed to have the work done by contract, proposals being invited in the usual way and award based on the amount for which the bidder proposes to clear the river, as indicated, from the railroad bridge to its mouth.

The original estimate for the work was $9,900, or $4,900 more than the amount appropriated, and it is therefore recommended that an additional appropriation of $4,900 be made for the fiscal year ending June 30, 1882.

The commercial importance of the stream was set forth in report of the survey. The work is not considered permanent, as the obstructions to navigation, caused by drift-logs, snags, &c., may be replaced by others of a similar character from caving banks and other causes.

The work is located in the collection district of New Orleans, and the nearest light-house is at the entrance of Atchafalaya Bay.

Original estimated cost	$9,900
Amount appropriated	5,000

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00
Amount (estimated) required for completion of existing project	4,900 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	4,900 00

M 7.

IMPROVEMENT OF BAYOU TERREBONNE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $10,000 was made for its commencement.

It is proposed to expend this sum in obtaining a 4-foot navigable channel down the bayou from Houma. To do this it will be necessary to clear away the overhanging willows and bushes on the right bank of the bayou for a distance of 20 miles below Houma and to dredge the shoal spots that exist at intervals for a distance of 6 miles below that place.

The work to be done by contract.

The work is not considered permanent, as the shoals below Houma are apt to reform with each high-water.

The original estimate for this work was $18,800, or $8,800 more than the amount appropriated. A further appropriation of $8,800 for the fiscal year ending June 30, 1882, is therefore recommended to continue the work of improvement and maintaining a navigable channel 4 feet in depth from Houma down.

The commercial importance of the bayou was indicated in the report of the examination.

The work is located in the collection district of New Orleans. The nearest light-house is near the east end of Timbalier Island.

Original estimated cost	$18,800
Amount appropriated	10,000

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	8,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	8,800 00

M 8.

IMPROVEMENT OF BAYOU TECHE, FROM SAINT MARTINSVILLE TO PORT BARRE, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $6,000 was made for its commencement.

It is proposed to expend this money in the work of improvement by removing from the bank all trees to a distance of 50 feet from the middle of the bayou; also to remove all trees, logs, snags, wrecks, and other obstructions from the bed of the bayou to 5 feet below low-water surface, or where such depth of water does not exist to the bottom of the bayou, and placing them on the banks above high-water or burning them, so that they shall not again become obstructions to navigation.

From Leonville to Port Barre, 13 miles, there has not been sufficient water for navigation within the memory of the oldest inhabitants, except during the extreme high-water of 1874. At the time of the examination, the low-water surface at Leonville was 4½ feet above that in the Courtableau, while 4 miles from Port Barre *the bottom* of the channel was 6 feet above low-water in the Courtableau.

For these reasons it is not deemed advisable at present to expend any of the appropriation for this year in improving the bayou above Leonville.

The work to be done by contract.

The original estimate, which was for improving the bayou from New Iberia to Leonville, provided for 3 needle-dams and locks, by which good navigation would be secured during the year, at high-water the dams being removed; and it is recommended that an appropriation of $50,690 be made for the fiscal year ending June 30, 1882, to complete the improvement.

The small bars found in this bayou are caused by draining ditches, and some means should be adopted to stop this and have the drainage ditches run into the swamps instead.

The work may be considered of a permanent character, in the ordinary acceptation of the term permanent as applied to works of this kind, if with needle-dams and locks; otherwise not, as the obstructions, caused by trees, logs, and snags, are liable to reform.

The commercial importance of the work is set forth in the report of examination.

The work is located in the collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Original estimated cost	$50,690
Amount appropriated	6,000

Money statement.

Amount appropriated by act approved June 14, 1880	$6,000 00
July 1, 1880, amount available	6,000 00
Amount (estimated) required for completion of existing project	50,690 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	50,690 00

M 9.

IMPROVEMENT OF BAYOU COURTABLEAU, FROM PORT BARRE TO ATCHAFALAYA, LOUISIANA.

This work originated in an examination authorized by act of Congress approved March 3, 1879, a report of which, together with plan and estimate for improvement, was published in House Ex. Doc. No. 54, Forty-sixth Congress, second session.

By act of Congress approved June 14, 1880, an appropriation of $7,500 was made for its commencement.

The principal obstruction in this portion of the Courtableau is Little Devil Bar, near its junction with the Atchafalaya. The bar varies in length at different seasons of the year, and at times is perfectly dry.

To remove this bar by dredging would only benefit navigation for one low-water season, as the succeeding high-water would cause it to reform.

To remove this bar and prevent its reforming it is proposed to close the run-out bayous to the south, of which there are 33, between Port Barre and the Atchafalaya. Before this can be done to advantage, however, a detailed survey of the locality is deemed necessary to determine the best positions for the dams and the proper height to be given them, a necessity stated in the report of examination. A plan and estimate for such a survey, and the reasons for making it, were forwarded for approval July 8, 1880.

To further insure low-water navigation to Washington with Little Devil Bar removed, there will be required a lock and needle-dam about 4 miles below Port Barre, and the commercial importance of the stream is deemed sufficient to warrant the additional expense for its construction.

In case it is only proposed to improve that portion of the bayou between Port Barre and the Atchafalaya, the following will be the estimated cost:

PORT BARRE TO ATCHAFALAYA.

Clearing the bayou of snags, &c., 18 miles	$900
Closing run-out bayous	20,000
One needle-dam and lock	15,000
Contingencies, 10 per cent	3,590
Total	39,490
Original estimated cost	39,490
Amount appropriated	7,500

It is recommended that $31,990 be appropriated for the fiscal year ending June 30, 1882, to complete the work.

The commercial importance of the work was indicated in the report of examination.

The work is considered to be permanent in the ordinary acceptation of the term as applied to works of this kind.

The work is located in collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Money statement.

Amount appropriated by act approved June 14, 1880	$7,500 00
July 1, 1880, amount available	7,500 00
Amount (estimated) required for completion of existing project	31,990 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	31,990 00

M 10.

IMPROVEMENT OF BAYOU LAFOURCHE, LOUISIANA.

This work originated from surveys authorized by act of Congress approved March 3, 1873, for report of which see Report of Chief of Engineers, United States Army, for 1874, Appendix R 13, and Report of Chief of Engineers, United States Army, for 1875, Appendix S 5.

Under act of Congress approved June 18, 1878, appropriating $10,000, a portion of the work was commenced. (See Report of Chief Engineers for 1879, Appendix K 3.)

By act of Congress approved March 3, 1879, a further appropriation of $10,000 was made available, and with a portion of this and a balance of the preceding appropriation, work was continued during the past fiscal year. (See this report.)

By act approved June 14, 1880, an additional appropriation of $5,000 was made for continuing the work.

The close of the fiscal year of 1878 and 1879 found the work suspended on account of high water in the bayou. Work was resumed on the 15th of July, 1879, the water in the bayou then having fallen to what was considered a suitable stage for recommencement of work of removal of such obstructions as snags, stumps, raft heaps, and wrecks.

On this kind of improvement work was continued until December 23, 1879, when it was suspended, as was done the previous year, because of too high water to work to advantage, leaving much yet to be done in this direction.

The work done during the season favoring (135 working days) is summarized as follows:

Wrecks removed	10
Snags and stumps removed	747
Logs removed	80
Actual working days	106
Days lost from sickness, from moving from place to place, and from delay for repairs	19

The field of work extended from Thibodeaux to a point 3 miles below ockport.

The work has gained in importance during the year, because of a canal connection made between the Lower Lafourche and Upper Barataria Bay, and thence to New Orleans through the bayous and canals connecting the bay with the Mississippi River, opposite New Orleans. This makes the low-water navigation of the bayou in a large measure independent of the long shoal at its head, which, as I have before reported in effect, it would be money thrown away to attempt to dredge out.

It is now proposed to simply continue the work of removing obstructions, as during the past year, from 3 miles below Lockport down to this canal, to benefit this portion of the bayou as much as possible; the work to be done as reported herein by hire of labor and purchase in open market. This will serve all the large interests below Thibodeaux, particularly those of the rice farmers, an interest that has greatly increased within the last few years.

I have everything on hand necessary for continuing the work, except the labor, which is to consist of an overseer and a crew of 12 men.

The stage of water in the bayou will soon be suitable for recommencement.

The work, so far as that portion contemplating removal of obstructions is concerned, may be considered as susceptible of permanent completion.

The work is located in the collection district of New Orleans. The nearest light-houses are those at the mouth of the Mississippi and at the entrance to Atchafalaya Bay:

Original estimated cost	$100,100 00
Amount appropriated	25,000 00
Amount expended	11,994 83

As the unexpended balance of the amounts already appropriated is deemed sufficient to complete the work of improvement under the present project, no additional appropriation for the fiscal year ending June 30, 1882, is recommended.

Money statement.

July 1, 1879, amount available	$13,817 81	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$18,817 81
July 1, 1880, amount expended during fiscal year	5,726 59	
July 1, 1880, outstanding liabilities	86 05	
		5,812 64
July 1, 1880, amount available		13,005 17

M 11.

IMPROVEMENT OF SABINE PASS AND BLUE BUCK BAR, TEXAS.

SYNOPSIS OF HISTORY.

An examination of this pass was made during the fiscal year ending June 30, 1873, report of which was forwarded to the Chief of Engineers with my annual reports for that year.

In compliance with instructions from the Chief of Engineers, dated January 20 and 23, 1875, I submitted, February 4, 1875, report with plan and estimates "for the improvement of the navigation of the harbor and bar at Sabine Pass, Texas." (See Report of Chief of Engineers for 1875, Appendix S 10, pages 945 to 947.)

In the act of Congress approved March 3, 1875, $20,000 were appropriated for the work, which was let out at contract but the contractors failed in their agreement, and the contract was annulled.

Under act of Congress approved August 14, 1876, appropriating $38,000 and balance of the appropriation for 1875, the work was again advertised for contract, but as it was estimated that the lowest responsible bid received would not complete a channel of the specified depth of 12 feet, all bids were rejected and the United States dredgeboat Essayons, lying idle at New Orleans, was sent to perform the work.

The Essayons, after about half completing a channel through the bar ranging from 12 to 15 feet in depth, became disabled by the unexpected failure of her boilers, and was ordered to New Orleans for repairs.

The disastrous result attending an attempt to substitute the McAlester is reported in my annual report of last year. (See Report of Chief of Engineers for 1878, Appendix J 4, pages 609 and 610.)

Repairs to the boilers of the United States dredgeboat Essayons, reported in progress in my last annual report, were completed and the

vessel sailed for Sabine Pass August 7, 1878, to continue the work of dredging—

1st. In deepening and widening the channel across the outer bar, and then

2d. Excavating a channel across the reef that separated the harbor of Sabine City from the roadstead inside of the outer bar.

The work was continued until February 7, 1879, when operations were suspended and the Essayons ordered to New Orleans.

The reasons for suspension and other particulars are given in the Report of the Chief of Engineers for 1879, Appendix K 4.

At the close of the fiscal year ending June 30, 1879, the dredgeboat employed on this work remained laid up at New Orleans and in good condition, awaiting further appropriation, and with a balance of appropriation on hand of $18,409.23, which amount was not considered sufficient for resuming the work during the fiscal year ending June 30, 1880.

During the past year, therefore, the work has remained suspended, with exception of that required for care of the very valuable property pertaining to it.

This property, with all the care that could be given it, is not to-day in as good condition as it was this time a year ago, and before being again actively employed will require some further repair.

By act of Congress approved June 14, 1880, further appropriation of $50,000 was made for this work *and* Blue Buck Bar. With the balance of last year's appropriation now on hand this gives for re-commencement of work during the present year the total of $64,775.14, which amount can be expended during the year in dredging to some advantage, but is not considered large enough to continue the work throughout the year. One hundred thousand dollars was the amount recommended, and the recommendation was made with a full knowledge of the necessities of the case.

It is proposed during the fall season of the present fiscal year to place the dredgeboat Essayons again in commission and employ her exclusively in deepening and widening the channel across the outer bar, for so long a time as the means afforded and the proper care of the dredge afterward will permit.

The rider on the work, viz, Blue Buck Bar, has no further right to connection with it than that given by association in the act of appropriation.

The condition of this so-called bar in Sabine Lake, above Sabine Pass and Harbor, was made the subject of special survey and report in 1872 (see Report of Chief of Engineers for 1873, Appendix Q 10), when it was found that there was 6 feet of water over it at mean low tide; a little greater depth said to be available through the lake, and 3½ feet over the bars of the Sabine and Neches rivers at the head of the lake.

The navigation over Blue Buck Bar is now governed by that over the river bars, which latter have recently been improved to give 5 feet navigation, which is yet less depth than that shown over Blue Buck by the survey of 1872.

It is, therefore, proposed to treat the rider in its connection with the Sabine Pass work by a simple examination and special report afterward, and by recommendation that it be permitted to stand upon its own merits.

It is thought that there is a growing demand for some good harbors on the Gulf coast west of the Mississippi. I have, in effect, said this so often in previous reports that it may at first appear superfluous to say it

again. I mention it because during the past year I have had to answer many inquiries relative to Sabine Harbor.

I have answered, in effect, that the location is good; the harbor capacious and susceptible of enlargement, land-locked, and safe; the bar at its entrance susceptible of improvement to any degree desired and at comparatively small expense; the country immediately tributary suited for development, and the rapid growth of Texas and of the countries north and westward, with their railroad connections, such as appeared to warrant improvement of the harbor and its entrance.

It will be seen from this expression of opinion that I think it desirable that suitable appropriation be made for works of improvement at the entrance to the harbor.

I therefore recommend appropriation for continuing the work during the year ending June 30, 1882, to the amount of $114,317, the amount to be made available for works to be designed for rendering the present work permanent.

The results of the work of dredging during the present year while in progress will enable preparation of detailed plans for works assuring permanency of the dredged channel.

The latter, as was stated in my report for 1879, cannot be considered as permanent unless it be given some lateral protection.

The work is situated in the collection district of Galveston, and the nearest light-house is at the entrance to the pass.

No commercial statistics have yet been obtained.

Original estimated cost	$390, 317 00
Amount appropriated	163, 000 00
Amount expended	98, 224 86

Money statement.

July 1, 1879, amount available	$18, 409 23	
Amount appropriated by act approved June 14, 1880	50, 000 00	
		$68, 409 23
July 1, 1880, amount expended during fiscal year	3, 542 89	
July 1, 1880, outstanding liabilities	91 20	
		3, 634 09
July 1, 1880, amount available		64, 775 14
Amount (estimated) required for completion of existing project		114, 317 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		114, 317 00

M 12.

EXAMINATION OF VERMILLION RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer W. H. Hoffman of an examination of Vermillion River, Louisiana.

The act of Congress approved March 3, 1879, provides for a survey or examination of Bayou Vermillion, but as the stream is called Vermillion River on the maps of this State it is so termed by Mr. Hoffman in his report.

Tracings of a chart drawn to a scale of $\frac{1}{5000}$ will be forwarded in a separate package.

The recommendations of Mr. Hoffman as to plan of improvement are set forth in his report, and are concurred in. His estimates are also approved, the total amount of which, viz, $9,900, could be expended to advantage on the work during the ensuing fiscal year.

The work is not susceptible of permanent completion.

I am unable to furnish valuable information concerning the commercial importance of this work.

It is located in the collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. H. HOFFMAN, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: I have the honor to submit the following report on the examination of the Vermillion River:

A transit and stadia line was carried from Pin Hook Bridge, which is the present head of navigation, to the mouth of the river, a distance of 49 miles; soundings were taken, and topography and all obstructions noted. Vermillion River starts from the junction of Bayou Barbeaux and Bayou Fusilier, and by the Fusilier it is connected with the Teche. The river flows through what is known as the Attakapas region, a high, slightly-rolling prairie country. The banks, for 42 miles below Pin Hook Bridge, are of red clayey soil, above all overflow, except strips of marsh occasionally found from 50 to 100 feet in width. Trees grow upon both banks for the first 42 miles to an average width of 100 feet, and are the only timber near. The remaining 7 miles to the mouth is sea-marsh, covered at high-tides. Pin Hook Bridge has no draw, but one could easily be made in it. Only at great freshets would there be water sufficient for navigation were the obstructions in the channel above, connecting it with the Teche, removed; but the supply of water is fully sufficient for slack-water navigation, with locks to retain the water at the height necessary for it to pass the Fusilier. The Vermillion, at Pin Hook Bridge, is wide and deep enough for small steamboats. The tide in the Gulf determines the height here entirely, except during freshets. There is a slight current at low tide. The right bank is about 20 feet high at the bridge, and the left 5 to 7 feet. The first 4 miles is now so filled by snags, logs, and trees blown in during the September gale as to be impassable. There are also many overhanging trees on the banks. A shoal at the end of the second mile is caused by a prairie coulée, and has but 2 feet water at low-tide. At Four-mile Point the steamers now stop and transfer freight for Vermillionville to flatboats, which are poled up to the bridge. The river below, to the ninth mile, is narrow and much obstructed by overhanging and fallen trees and snags. There are also four shoals, the first of which is but 10 feet long, and appears to be of logs across the bayou, having but 2 feet over them at low-water, and 4 feet on either side. The next is caused by a ditch from the high land, the other two by prairie coulées. These shoals cause much delay to steamers, as they can cross only at high tide; their removal by dredging and closure of the channels causing them will help navigation. From the ninth to the twentieth mile the least depth is 4 feet at low-water, which is sufficient for the boats in the trade. There are a few snags and some overhanging trees. Below the twentieth mile the river gradually increases in width and depth to its mouth; the only obstructions are a few snags. Abbeville is on the twenty-fourth mile, and is the largest town on the river, and the shipping point for the region to westward. The river enters Vermillion Bay in a little cove at its western end, which is a good harbor at its mouth; but there is a shoal bar between this cove and the bay, over which the depth at low-tide is but 2 feet. The channel could probably be improved by making a jetty of brush or cane fascines from the shore to the island, shutting off the incoming current over the mud flat at rising tide and forcing it to follow the course taken by ebb-tide, which is the channel followed by boats. A chart of the river is made on a scale of $\frac{1}{5000}$.

The estimated cost of improvements below Pin Hook Bridge is as follows:

Clearing and removal of snags 5 miles from bridge, at $200	$1,000
Clearing and removal of snags next 15 miles, at $100	1,500
22,000 yards dredging at mouth, at 25 cents	5,500
Jetty	1,000
Engineering and contingencies, 10 per cent	900
Total	9,900

The commerce to be benefited is that of Vermillionville and Abbeville, with the surrounding country.

Yours, respectfully,

W. H. HOFFMAN,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF BAYOU TECHE, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith the report of Assistant Engineer H. C. Collins, of an examination of Bayou Teche, Louisiana, provided for in act of Congress approved March 3, 1879.

Tracings of chart, drawn to a scale of $\frac{1}{5000}$, will be forwarded in a separate package.

Recommendations of Mr. Collins as to plan of improvement are set forth in his report and are concurred in. His estimates are also approved. The whole amount can be expended to advantage during the ensuing fiscal year, viz, $58,190.

I am unable to furnish valuable information concerning the commercial importance of the work.

It is located in the collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: After delivering to Mr. Elms the instruments and instructions for the survey of the Courtableau, I made an examination of the Teche. Mr. Harrod, the State engineer of Louisiana, gave me the notes of a compass line and the level notes which had been taken on a survey made by Mr. d'Hemecourt and Mr. Elms. As this survey had been made so recently, it was only thought necessary to go over the country and take the notes of topography and soundings and get some other information which was not contained in the notes.

Mr. Harrod's survey extends from Washington, on the Courtableau, to Saint Martinsville. A survey was made by Mr. Duke, under your direction, in 1870, and I had a tracing of this chart also, to see what changes had been made below Saint Martinsville since it was before surveyed, and the present obstructions in it. It was extreme low-water in all the west delta bayous at the time of the examinations in August, 1879, as there had been an unusually long drought, and there is probably never any less water than there was at that time. Bayou Teche leaves the Courtableau at Barry's Landing, but the upper portion of it so filled that no water runs down it with less than an 8-foot rise of the Courtableau, and with a rise of 15 feet the channel leaving the

Courtableau has a surface width of but 30 feet. Small as this channel is, a large part of it for the first 4 miles is filled by standing trees, which grow even down to the bottom of it, and with overhanging trees, bushes, and logs and fallen trees. The banks are above the high-water of 1874, which was the highest known. They are entirely of Red River deposit. During the high-water of 1874, flatboats loaded with lumber and fencing material passed down through this channel, but it could only be used at very high water, when the lower willow trees were so covered with water that boats could bend them down and pass over them.

For the greater part of the year only a little stream of water, the drainage of the springs in the bank, finds its way down this channel, and 4 miles from the Courtableau the bottom of the channel is 6 feet above low-water in the Courtableau. How much higher the top of the divide is, there is no data in the notes to show. At Leon's Bridge, which is 13 miles from the head of the Teche, the extreme low-water surface at the time of the survey was 4½ feet above the low-water surface in the Courtableau, and it was at the time backwater, all entering from above the bridge being so little as barely to supply the evaporation in the pool of 6 miles backwater above the mouth of the Fusilier.

Mr. Harrod's survey was not made by way of Barry's Landing, but left the Courtableau about a mile below Washington, passing up the Caron for 2 miles to the head of the Maricoquant, which runs to southward from the Caron. Above this point the Caron is but a rainwater channel; and, below, its banks are like those of the Courtableau and Teche of Red River deposit, as are those of the Maricoquant, which from the Caron to the junction of the Teche, 4 miles from Barry's Landing and 9 miles from the Caron, is but a small channel, and at the high-water of 1874 it had but 4½ feet depth on the top of the ridge over which it runs, just below the place where it leaves the Caron. It is much overgrown with trees, and there is no chance for any navigation by it. For the 9 miles it only consists of a series of pools, except during very high water.

The fall from the fourth mile to the thirteenth in the Teche is but little, but the channel is much obstructed by trees standing in it. The banks are everywhere above the high-water of 1874, and are bordered by cultivated fields for much of the distance. A road follows the top of the bank on each side of the bayou, and from the extreme bottom to the road trees are quite thick. At the nineteenth mile the Fusilier enters from the west, and from it comes the entire low-water supply for the Teche.

At the time of the examination in August the cross-section of the Fusilier was 175 square feet at its mouth, and the velocity of the current was about 2 feet per second.

There are large cypress swamps a short distance up the Fusilier which act as reservoirs and prevent any sudden rise of the stream at its mouth, though above the swamps it must be subject to great fluctuations, as it takes the drainage of a large area of prairie and hill country. There is a channel which forms the head of the Vermillion, and when the Mississippi is very high and much water comes down the Teche from the Courtableau, the current runs up the Fusilier and down the Vermillion. The banks of the Teche like those of the Courtableau at Washington are several feet above the highest floods. The overflow from the Lower Courtableau covered the land east of the Teche to within a few hundred feet of the top of the ridge forming the bank of the Teche. the drainage being from the Teche towards the Atchafalaya bayou and lakes. I was told that they nowhere connected except, possibly, through some ditches. Mr. Elm's levels gave the fall in the Teche from Arnaudville at the mouth of the Fusilier to Saint Martinsville as 10.2 feet. The distance is 30 miles. Breaux Bridge is 15 miles below Arnaudville, and 7 feet of this fall is in this 15 miles. The remaining 3.2 feet is between there and Saint Martinsville. Except at lowest water a small steamer runs from Breaux Bridge to Saint Martinsville and connects there with larger ones which run on the Teche below at all stages of water.

Between Arnaudville and Breux Bridge there is an almost continuous line of overhanging trees on one or the other side of the bayou, and in many places on both sides. There are also many logs, the remains of old live-oak trees which had fallen in. The channel is also much obstructed by bars at the entrance of drainage canals or ditches which have been cut into the bayou from fields on its banks to save long drains back, and in rains much mud from the alluvial soil of the fields is washed into the bayou. These ditches are all quite recent and the bars are yet but short, though filling usually about half the cross-section at low-water. In some cases there was a bar 100 feet long, but seldom more than 40 or 50 feet in length. Between these bars there was usually 3 to 6 feet depth and a width of 40 to 70 feet. At the height of the flood of 1874, the bayou was here 200 to 350 feet wide. The depth is greater on tops of these drainage bars below Breaux Bridge, and it is seldom at extreme low-water less than 2 feet, and the pools between have 5 to 8 feet depth with a width of 40 to 80 feet. The high-water cross-section is very nearly the same as that above as far down as Saint Martinsville.

There are no short bends, but the bayou runs in long sweeping bends with gentle curves. From Saint Martinsville to New Iberia I counted 41 snags, which are more

or less obstructions, and 5 stumps of trees which have been cut off too high, and at some stages of water form very serious obstructions. There are 16 of the bars caused by drainage ditches, which will, if they are to be removed, require each an average excavation of about 500 cubic yards; some of these bars would be much less than this, and can now be passed with no trouble, but all are growing with every hard rain. There are not more than 20 standing trees which would need removal. There is one wreck at Saint Martinsville, which is very much in the way at very low water, but only one side requires to be taken off; this would leave sufficient room for passage. Only stern-wheel steamers run above New Iberia. For nearly 10 miles above New Iberia the depth at extreme low-water is 6 to 12 feet. The banks are but little washed and there has been no other shoaling than that due to the drainage canals; but at New Iberia the condition of the bayou changes entirely. The width and depth I was told were formerly very much like the first 10 miles above, but now the width is nearly double what it formerly was, and for several miles its low-water depth is but 2½ to 4 feet, and the depth is almost exactly the same for nearly the entire width of the bayou. The cross-section above New Iberia is a natural one, deep in the middle and shoaling towards the edges gradually. The cause of this injury to the bayou must be determined before any plan can be made for the improvement of it. The entire change, so far as it obstructs navigation, has taken place since 1860, but it was probably in progress for years before that time, unnoticed because it had not interfered with the navigation. When the banks were cleared and roots of the trees gradually rotted, it was less protected from washing than it had been while lined by almost a continuous row of cypress trees. Side-wheel steamboats, such as are used below New Iberia, and not above, are so constructed that there is a strong current from their wheels washing the bottom from some distance away from the mid-channel out to the banks, but no current at all in the middle, consequently the heavier portion of the material washed up is deposited in mid-channel behind the boat, and the swell of the boat, which is greater than that from a stern-wheel boat, washes the banks, and causes the widening of the surface. The stern-wheel boat spends the force of its engine on the one wheel at its stern, and the current from it washes up the bottom in the center of the bayou only, and the tendency of the heaviest part of the material washed up would be to the more quiet water of the sides. So it would have a tendency gradually to improve the navigation, while the side-wheel boat far more rapidly destroyed it. Were the bayou wide, so that boats took different paths in passing up and down stream, it would probably make little if any difference whether side or stern wheel boats were used, but the Teche is so narrow that all boats follow very nearly one path. The fall from New Iberia to the Gulf is probably but very slight, as the current is up or down with the tide at low river, and there is a sufficient depth from a few miles above Charenton down to the mouth of the bayou for all navigation. There are no overhanging trees and very few snags below New Iberia, they having been removed in 1872 and 1873, under an appropriation by Congress.

The only means available to make good navigation of the Teche for the year is to make such dams and locks as are recommended for the Courtableau, and except at high-water have slackwater navigation, giving locks a width of 45 feet in the clear so as to allow the passage of stern-wheel boats, but not wide enough to allow side-wheel boats to pass.

The abutments of these locks would remain during high-water, but the gates would be open and the needles of the dams removed for free passage of the current, so that the sediment deposited would be swept out, as at present, at high river.

The data of the level-line and other information obtained shows that 3 locks with about 7 feet lift each will carry good low-water navigation to Leon's Bridge. If conditions remain as they have been for the past ten years, the end of all low-water navigation in the bayou does not appear to be very distant. The present low-water supply of the Fusilier is ample for lockage, but an increase of it to almost any required extent can be had by storing the flood supply in the cypress swamps above Arnaudville on the Fusilier. The only limit would be the amount of evaporation in protracted droughts, and the one of July and August, 1879, was an unusually long one, yet there was a discharge at Arnaudville of 350 cubic feet per second; it was greater there than below, as that was the only water entering it at the time.

Any attempt at connecting the Teche and Courtableau by slack-water navigation up the Teche would require such an amount of dredging as would make it impracticable, and the supply of water at extreme low stages might be found insufficient for lockage. With the improvements made in other directions this would not be needed.

The commerce of the Teche is very great. The entire supplies of a large part of the best portion of Louisiana are received by this route, and the fuel, fencing, and material for buildings, as well as all ordinary supplies, are brought up the stream; the exports being sugar, cotton, cattle, and many other products which are shipped chiefly to New Orleans. I was told that the Teche country produced more sugar than any other equal area of the State, and that it is possible with increased facilities for production, such as cheaper freights and possibility of shipment at any time of year, to increase the sugar

crop of this region to far more than the present entire production of the State. The navigation of the Teche is so connected with that of the Atchafalaya and the various routes of communication between that stream and the Mississippi River, and also with improvement of the other delta bayous De Glaise, Courtableau, Atchafalaya, Plaquemine, and Vermillion, that one general plan should be adopted and carried out, viz. making slackwater in the various smaller bayous, and connecting all of them with the great central channel of the Atchafalaya at different points, and providing for its permanent connection with the Mississippi, either through Red River or Plaquemine.

The estimate for improving the Teche would be as follows:

Removing snags and stumps between New Iberia and Saint Martinsville	$1,500
Removing snags and trees from Saint Martinsville to Breaux Bridge, 15 miles, at $100 per mile	1,500
Removing snags and trees from Breaux Bridge to Arnaudville, 15 miles, at $200 per mile	3,000
Removing snags and trees from Arnaudville to Leon's Bridge, 6 miles, at $150 per mile	900
Dam and southwest outlet of the Fusilier swamps	1,000
Three needle dams and locks, at $15,000 each	45,000
Engineering and contingencies, 10 per cent	5,290
Total	58,190

No estimate is included in the above for dredging, but it is because if slackwater navigation is determined on there will be sufficient depth on these bars, and by closing ditches and turning drainage in the other direction, the bars will probably disappear. It may be found that on deepening the upper portion of the bayou by raising the water-surface there will be some little dredging of bars needed below the lower dam to make the increased depth above available; but if so, and if a change in the class of boats to stern-wheel boats should not of itself remedy the evil of these bars, it will be soon enough then to dredge the few lower bars when the locks are made.

A chart of the survey is made on a scale of $\frac{1}{6000}$, as far down as Saint Martinsville, below which the chart made by Mr. Duke gives all the available data.

Yours, respectfully,

H. C. COLLINS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF BAYOU COURTABLEAU, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer H. C. Collins on examination of Bayou Courtableau, Louisiana, provided for in act of Congress approved March 3, 1879. Tracings of chart drawn to a scale of $\frac{1}{5000}$ will be forwarded in a separate pakage.

The recommendations of Mr. Collins as to plan of improvement are set forth in his report, and are concurred in. His estimates are also approved; $60,000 could be expended to advantage on the work during the ensuing fiscal year.

The work will constitute a permanent improvement in the ordinary acceptance of the word permanent.

The importance of the work and all information obtainable concerning the commercial statistics are given in the report of Mr. Collins.

The work is located in the collection district of New Orleans. The nearest lighthouse is at the entrance to Atchafalaya Bay.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: I have the honor to submit the following report of the examination and surveys of Bayous Boeuf and Courtableau, from the head of the Lamourie to the junction with the Atchafalaya River.

The bayou, though having two names in different parts of its course, is really one stream, and has been so considered in making this examination. Its former source was the Red River, and it empties into the Atchafalaya River.

Bayou Robert, which once brought the water from Red River and furnished a large portion of the water of this bayou, was closed many years ago, and with it all upper connection with Red River ceased. The water at low stage, which now forms the stream at the beginning of this survey, comes from the pine woods hills on the south side of Red River and to the westward of the bayou. Above the beginning of the survey is a large cypress swamp, which forms a reservoir and prevents any sudden floods from rains in the hill country.

At the low-water stage of the bayou about two-thirds the water coming from above is lost down the Lamourie.

A very small portion of the water now running down the Lamourie would suffice for all necessities of the few plantations on its banks; and closure of the bayou at its head, excepting what water was needed for them, would give fully double the present amount in Bayou Boeuf.

The banks and country on each side of the Boeuf are of red soil, which is evidently the deposit of Red River. The banks are nowhere caving, and are several feet higher than the highest floods.

The descent is from the immediate banks, away from the bayou on each side, to low cypress swamps.

The slope varies greatly, as the banks of the bayou are very uniform in their height, as are the cypress swamps, and the distance from the bank to the swamp varies between one-quarter of a mile and 3 or 4 miles. No levels were run across the valley to determine the differences of level between the top of the bank and the cypress swamp back of the fields, but it is probably 12 or 15 feet.

The bayou runs in great, sweeping bends, such as would be formed by a stream larger than it now is, and it had at some time sufficient water supply to overflow its banks at high river, and sufficient current to wear away its banks, as the bends are such as are made by caving banks.

Since the present conditions have been in operation the banks have become covered with trees and bushes from their tops to about the low-water line, and in many places cypress trees of great size have grown in the bed of the stream or on its immediate banks, and where they have been cut their stumps remain as low-water obstructions.

The banks are everywhere cultivated, from the top of the ridge near the bayou, back near to the cypress swamps.

Drainage is back to the swamps except in those bends where cut-offs had almost taken place at the close of the period of caving banks.

The lands are very fertile, and immense crops of cane, cotton, and corn are raised.

The bayou, at the low-water stage, is very much too small for 90 miles above Washington for navigation, even with the smallest boats, as it is but 1 foot in depth in many places, and any deepening of these places would but draw off the water of the pool above, and perhaps transfer the position of the shoal, but not in the least increase the depth for purposes of navigation.

Closure of Bayou Lamourie would furnish water enough to make a low-water channel of 2½ feet, except at periods of long droughts, and were the logs in the bed removed and the overhanging trees cut, would probably afford a depth of 4 feet or more for the winter months, when there is most rain.

The small barges which are at present used can take freight on this depth, and the steamers can tow them; but for any really useful low-water transportation, locks and slackwater navigation will be needed. The survey of the upper portions of the bayou to within a few miles of Washington was made by Mr. George O. Elms, and that below was made by myself, with his assistance.

The cross-section made above the head of Lamourie gives a low-water area of 540 square feet in the pool where the cross-section was made.

At the extreme high-water of 1874, 3,040 square feet area and the tops of the banks 8 feet higher would increase this cross-section area, if they were full, 2,720 square feet, showing that the channel is capable of carrying double the water found in it at the highest floods.

The cross-section of the Lamourie, nearly 2 miles below its head, gave an area in the pool at low-water of 100 square feet, and at the height of high-water of 1874 of 620 square feet. The tops of the banks were 3 feet above this height.

The depth on the first ripple below the Lamourie, on the Boeuf, was but 1 foot, and

its extreme width but 40 feet, giving a cross-section area at extreme low-water of but 28 feet.

The entrance of Bayou Clear, at the middle of the fourth mile, rather more than doubles the amount in the Boeuf. It comes from the hills west of the delta valley.

On the twelfth mile is a small bayou which enters from the west. Below this all the west side drainage goes to the Cocodrie Swamps, which here form the west side of the valley and border on the west hills. That on the east side finds its way through swamp channels to Bayou Huffpower and Bayou Rouge.

No stream enters and none leaves until we reach the Huffpower, on the forty-third mile, which is an old channel leading to the westward, and much more filled by late deposits than the Boeuf, and is dry at its head, with a rise of less than 7 feet in the Boeuf. It therefore does not in the least injure navigation in the Boeuf, as when there is a 10-foot rise but a very small stream runs down the Huffpower, and there is no risk of its again cutting out to take any large amount of water from the Boeuf, as it is decreasing and has little fall.

The banks are almost perfectly uniform from here to the mouth of the Cocodrie, which enters from the west at the end of the eighty-sixth mile, and below the mouth of which the name is changed to Courtableau.

The cross-section is almost exactly the same as at the head of the survey. The banks are of equal height above the high-water marks, being everywhere covered with overhanging trees.

The bed of the bayou has many logs and stumps and some standing cypress and gum trees. There are frequent bridges, all of which have draws for passage of steamers. The depth on the ripples is but 1 foot at extreme low-water, and in its narrowest place the width is but about 20 feet.

The overhanging trees are so thick that a rise which would give good navigation were they removed will only permit small steamers with a width of about 20 feet to pass, and they have smoke-stacks with joints to lower for passing under low trees.

Some years ago a lock was begun by a stock company, under an appropriation from the State. It was located at the upper end of a shoal 600 feet long, which is found just above the junction of the Boeuf and Cocodrie. It would not have been of any use if it had been completed, which it never was, as when there was water enough to get to it there was enough to do without it. It now forms a slight obstruction where one corner projects into the channel, but it can be easily removed.

The amount of water coming down the Cocodrie at low-water is more than double that which comes in from the Boeuf. The west bank of the Courtableau here at its head is also the west side of the delta valley, and high bluffs form the west bank of the bayou, rising 100 feet or more within half a mile.

One mile below the junction a cross-section was taken, at a place where there was a current of about 1 foot per second at the time, which was extreme low-water. The low-water area was 180 square feet, and that at the height of the 1874 water-mark was 3,400 square feet; this was several feet below the top of the bank and is the highest water-mark observed.

Although the alluvial bank on the east side, and all that above, is nowhere caving, the bank does cave all along the bluff land at every place where the stream touches it.

The town of Washington has half a mile front on the bayou on the fourth mile, and the 3½ miles above it are lined with overhanging trees on both sides, and there are many logs in the channel as on the Boeuf above.

Washington is situated on the west bank on a bluff formation, and it is a place of much importance as a shipping point for a large amount of freight, and head of navigation for the larger boats during a great portion of the year.

There is a draw-bridge about the center of the town, and a cross-section taken from it gave a low-water area of 140 square feet, and at the height of 1874 high-water mark it was 3,590 square feet; the rise at that time was 23 feet above extreme low-water, yet was several feet below the top of the east alluvial bank.

There are very few overhanging trees below Washington, but near the middle of the fifth mile is a saw-mill, where for nearly half a mile the old saw-logs and butts of logs which have been cut off and rolled in form a complete blockade, with less than a 3-foot rise. All of them must be taken out.

The shoalest places have about 2 feet of water at extreme low. On the sixth mile Bayou Caron joins the Courtableau from the west, and with less than a 12-foot rise of the Courtableau it runs into it, but there is a connection 2 miles above, through the Maricoquant, which, with a rise greater than that in the Courtableau, takes the water to the southward, to the Teche. The Caron to this junction, the Maricoquant, and the Teche below, all have the same banks of Red River formation as the Courtableau, but the Caron above this junction is merely a hill stream, with black or gray deposit from the bluffs.

At Barry's Landing, on the thirteenth mile, the Teche leaves to the southward, and at times of great floods carries off a large amount of water from the Courtableau, but

it is for the first 4 miles much obstructed and only runs at present with an 8-foot rise of the Courtableau.

It here bears marks of having once been far larger than it is at present. About the middle of the seventh mile Bayou Toulouse once ran out of the Courtableau and emptied into the Teche, but a dam has been made across its head and a ditch cut from it across the bottom land, entering the Courtableau near the beginning of the tenth mile, and causing a bad bar.

At the beginning of the eighth mile the Little and Big Ouacksha bayous enter, near each other, from the north, and at high-water times bring in some water from Red River.

Small steamers always run up the Courtableau at low-water as far as the landing below the Ouacksha, and the depth between there and Barry's Landing is 6 to 10 feet, except where two drains enter, one from Bayou Toulouse and the other from the opposite side on the ninth mile. On each of these short bars is a depth of 3 feet at extreme low-water; both are of recent origin and can be removed by dredging or by removing their cause by closure of the ditches.

At Barry's Landing is a bar quite variable in its position, but which is caused by the high-water from Red River backing up the Courtableau and that entering from the north side bayous running across the Courtableau down the Teche. The bar is near the head of the Teche, and at times of discharge down it in floods there is little or almost no down current in the Courtableau past that point.

The surface of this bar is washed off as the bayou falls, and there is but seldom so little as 4 feet depth on it at lowest water.

At the time of the survey, the middle of October, 1879—at extreme low-water as it then was—there was a slight current, amounting to 1 foot per second, on the shoal places as far down as the eighth mile, but below that the current slackened until at Barry's Landing and below it was about 1 foot in 10 seconds, decreasing below as the cross-section at low water increases, until it is so slight that small objects on the surface float up or down as driven by the slighest breeze.

In a bend on the eighteenth mile the bank is so washed that a fresh surface is exposed on a slide, and for 8 feet above low-water the bank is of blue clay, which does not wash, overlaid by 10 to 15 feet of Red River formation. The old red deposit once put on this blue clay slope appeared to have recently slid or been washed in. Near the top of the blue clay were some roots of cypress, which did not reach up into the red land above, and in the red land above were a few pieces of ancient drift found, and more or less of them everywhere on the Bœuf. Every one of these which retained the substance of the wood enough to enable me to determine what it was I found to be red cedar, and in many cases a log or piece of drift, though blackened and soft for an inch in depth, had yet inside that a sound red cedar heart, retaining not only the color but the smell of the new wood.

The outer side of the bend next below this had the blue clay bank exposed by washing off of the red surface, and it was the same height above water. At Barry's Landing the high-water of 1874 is near 2 feet below the top of the bank on the south side, but 2 miles below it is at the surface, and on the seventeenth mile is 3 feet above on the narrow ridge on the south side, and so high as to wash away fences a few hundred feet south from the bank. Nearly the entire distance from here to the Atchafalaya was then covered.

The land on the north side of the Courtableau is somewhat lower than it is on the south. Below where the banks of the Courtableau were covered deeply in the flood of 1874 the general course of that flood was southward directly, following the channel of the Courtableau for short distances only as it ran in the direction in which it was moving, and often for short distances running up the stream.

Near the end of the nineteenth mile is a pile of oak logs, reaching entirely across the channel, and the part of it which had not been removed is about 6 feet above low-water. A channel through this barricade has been made by pulling out logs so as to give a low-water depth of 5 feet for a width of 50 feet.

Through changing their places in times of high-water these logs at times form an obstruction to navigation which may in some cases be quite serious; but the whole block of logs can be easily pulled out on the bank at low-water and burned.

At the bend on the south side, near the end of the nineteenth mile, the blue clay surface is 5 feet above water, and in the opposite bend, 500 feet above, it is at the same height, covered in both cases by about 10 feet of red soil. The surface of the blue clay, in both instances, was evidently a cypress swamp when the red deposit began to be made, and the channel in the blue clay was made before that time and was much longer than the present channel, as but one side of the present channel is worn into the blue clay, while the opposite is Red River deposit, like that above the blue clay, filling an unknown proportion of the ancient bed.

Te red soil, though resisting the washing of a current far better than that of the west bluffs of the valley at Washington, is easily washed compared with the blue clay.

On the twentieth mile Big and Little Darbon bayous enter from the north. Both have large channels, though bringing at low stages very little water. The Courtableau is here, at low-water, 100 to 150 feet in width, and 13 to 15 feet deep.

At the middle of the twenty-first mile is a south-side bayou, which runs with an 8-foot rise, and near the end of the same mile Bayou Jummel leaves on the south. A small sand-bar in its head is 3 feet above extreme low-water, but the channel is wide and at high-water has a large discharge.

The bottom lands, on each side, are 13 feet above extreme low-water, and a water-mark on trees was 5½ feet higher. The high-water mark appears to vary greatly, depending on the escape to southward of the water coming in from the north, and near the Jummel it was 1½ feet lower than a mile above.

Blue clay shows at every bend where the current meets any old bank.

Near the beginning of the twenty-third mile the bank on the north side is 12 feet high, but it falls before reaching the middle of the mile to 7 or 8 feet, and continues at that height, with some yet lower places, until the middle of the twenty-sixth mile, showing a strong current at high-river.

On the opposite south bank the high land has a break 1,200 feet wide, where the water runs with a 7-foot rise; it is much washed.

On the twenty-fourth mile two bayous leave on the south side, which run with a 5 to 8 foot rise, but the intervening land is 12 to 13 feet high.

The twenty-fifth mile has one bayou 60 feet wide and 5 feet deep at low-water at its head, but which is so choked below that no water escapes at extreme low-water. Three other bayous, which run with a 5, 6, and 7 foot rise, leave on the right bank on the same mile, but the land between is 15 feet high; 7½ feet of this is blue clay.

There are eight bayous on the south side on the twenty-sixth mile, the upper two of which run with a 2-foot rise; the next two with a 6-foot rise; next is Mamselle Bayou, which is 70 feet wide at low-water, but has no current at such time, though it is a very large stream at high-water; the other three are small bayous. Land between these is 10 to 14 feet high, and shows a strong current at high-water, though the surface is little washed, being thickly covered with trees and bushes.

On the left bank, at the head of the twenty-seventh mile is a high tract where blue clay shows 5 feet high, with 5 to 8 feet of red soil above it.

On the south side, a few hundred feet back from the bayou, at the head of the twenty-seventh mile, are two mounds 10 feet above the highest floods. Just below them the Fordoche Bayou runs out to the southward; its channel was 3 feet deep, but it had, at low-wate, no current. This was the channel for steamers previous to clearing out the raft from the Atchafalaya, and it forms a connection through Bayou La Rose with Grand Lake below, and there are many cross-channels between it and the Atchafalaya. It has not been used since the opening of the other bayous. On its south bank I found an old high-water mark, made by drift which was 9 feet above the surface where the bank was 13 feet high, showing that within 20 or 30 years a flood had risen here 22 feet above low-water. Blue clay on its bank is 7 feet and red soil 6 feet deep.

At the head of the twenty-eighth mile the right bank was 13 feet high, and this year's high-water mark 2 feet above it. Two narrow bayous run out with a 4-foot rise, and on the middle of the mile is a washed channel 1,000 feet wide, 3 to 6 feet above low-water. Much drift has lodged in it, which probably came from Bayou Bigrean, which by four mouths enters from the north. It is evidently a very large bayou at high-water, but no water enters from it at low-water. The entire distance, 2,500 feet, between its extreme mouths is a swamp but 3 feet above low-water and bearing marks of strong currents at flood seasons.

On the south side, at the beginning of the twenty-ninth mile, is a bayou which is entirely covered with standing trees, and its bed is but 3 feet above low-water. For one-half a mile below the blue clay is seen in the right bank 5 feet above water, with 4 to 5 feet of red soil above it.

One small bayou leaves at the end of this mile and one at the beginning of the next, and one enters from the north just opposite this last. Six hundred feet below, English ... leaves to the southward; it is 70 feet wide and 5 feet deep at low-water, but ... no low-water current. In its banks, and those of the river near, the blue clay ... feet above water, with 6½ to 8 feet of red soil above it.

... Fordoche Bayou leaves at the end of the thirtieth mile, and a bayou enters ... the north, directly opposite its head.

... pth of the Courtableau is here 18 feet, but it shoals very fast, and at the be... of the thirty-first mile it is but 10 feet, 400 feet below but 6½ feet, and 2,000 ... the beginning of the thirty-first mile it has shoaled to but 1 foot. This ... called Little Devil Bar. It is of a loose, easily washed sand, and extends to ... below the end of the thirty-first mile, being about 6,500 feet long at present. ... head of the bar a bayou enters from the north, and there is a mile of low ... h is but 3 or 4 feet above low-water and is said to be all bayou at high-

The south bank is high except at the bayous, which run with a rise of 3 to 4 feet. The entire surface on the south bank is 7½ to 14 feet above low-water. Floods from above on the Courtableau and from below on the Atchafalaya meet here and pass off to the southward through these bayous and over the bank. It is only at times of low-water in the Atchafalaya and high-water in the Courtableau that any water runs from the Courtableau into the Atchafalaya, except in extreme low-water. There is a current up over the bar whenever there is a rise of 5 feet above extreme low-water in the Atchafalaya.

The cross-section at low-water on the bar varies hourly with the washing away of sand in any particular place. The narrowest place at the time of the survey was 20 feet, with a depth of 2 feet, but the shoalest place was but 4 inches deep.

All low-water freight passes this bar from the small steamers above to the larger ones below by very light, flat barges; but there are many times when it is perfectly dry on the sand, and the whole upper discharge goes by one of the little bayous above, which were, at the time of the survey, so filled as not to run. Then freight is rolled over the bar. The transfer by either means is much more expensive than the entire freight from Washington to New Orleans with good navigation.

The position of this bar varies with the relative height of the two bayous, and it has been at the mouth of the Courtableau, though seldom much above its present position.

When there is low-water in the Atchafalaya and a freshet comes down the Courtableau, it sometimes sweeps the whole bar out into the Atchafalaya, and it passes away only to be replaced at the next succeeding high-river from the Atchafalaya.

From the lower end of Little Devil Bar to the Atchafalaya, is but three-quarters of a mile, and the depth at low-water is from 12 to 14 feet. This channel is 60 feet in width, but is bordered with standing trees and stumps.

The red deposit on which these trees grew has lately slid in, with its growth of trees, as far as the old blue-clay bank, and the present surface of the portion slid in is from 3 feet above to 10 feet below the low-water line. The blue clay is seen on both sides, 7 feet above low-water, with 5 to 6 feet of red soil above its surface on the left bank and 6 or 7 feet on the right bank. The entire fall across the bar at the time of the survey did not exceed 3 feet, and was probably much less, but no levels were taken. The fall from Barry's Landing to the head of the bar was not enough to give a discharge, at the time of the survey, of more than 60 cubic feet per second, which was the amount passing over the bar.

The width below Little Devil Bar between the surface of the blue-clay banks is 270 to 300 feet. Were the stumps and trees on the slides pulled out, the red soil of the slides would probably be soon washed out.

There are two small bayous on this three-quarters of a mile, both of which have high banks and are cut down 4 or 5 feet into the blue clay.

The left bank of the Atchafalaya, at the mouth of the Courtableau, has blue clay for 7 feet above low-water, with 7 or 8 feet of Red River deposit above it.

The cross-section of the Courtableau was taken just below the bar and at the mouth, and also that of the Atchafalaya just below. The area at low-water of the first of these cross-sections was 2,175 square feet, and at the level of the top of the bank it was 6,000 square feet; but the high-water mark was some feet above the top of the bank.

At the mouth of the Courtableau the low-water cross-section had an area of 2,160 square feet, almost exactly the same as that taken half a mile above; but at high-water here the bayou has but one bank, joining the Atchafalaya.

The low cross-section of the Atchafalaya was 5,160 square feet, and the current at the place was at least 1 foot per second.

At this time all of Red River and a stream from the Mississippi River, through the dredged channel, which gave at the time a discharge of about 360 cubic feet per second, ran down the Atchafalaya.

Were the banks filled, the cross-section of the Atchafalaya here would be increased 7,800 square feet, or to 12,960 square feet, but it rises in high-water seasons far above its banks, and Bayou Alabama had left the Atchafalaya above the Courtableau, and has a cross-section nearly as large as the Atchafalaya.

There was, in the flood of 1874, little, if any, land above water between the Atchafalaya and the Mississippi rivers.

The first obstacle to navigation in the Courtableau is Little Devil Bar, and it has been removed by natural causes two or three times already. By making works which will give the same conditions as those operating when the bar was washed out by these natural causes I think we can depend on reaching the same result. By a dam at each of the bayous on the south side, which would keep all the water of the Courtableau from running off to the southward, with a rise of less than 10 feet, and a levee where the height of the bank was below that, and so protecting their lower slope that water could safely run over whenever a flood should rise above that, we would not materially decrease the total amount of water discharge over the south bank in floods

like that of 1874, and would find that, at any time, as the water fell below the top of the leveed south bank, we would again have exactly the conditions necessary for natural removal of whatever sand had been deposited at the previous high-river season. Although, with a flood of sufficient height to raise the water very much above these dams, the current would, as at present, run from the Atchafalaya up the Courtableau for a distance, greater or less, exactly proportioned to the relative discharge of the two streams, and a large amount of sand would, as at present, be deposited in the Courtableau; yet, as soon as the height fell below the 10 feet, the entire discharge of the Courtableau would make a current sufficient to clear its own channel. It would not be desirable, were it possible, to build any such levee as would materially decrease the discharge of the valley directly down its slope across the Courtableau in floods, as it would but force more water on to the already deeply-covered region eastward of the Atchafalaya.

Before beginning any work it would be necessary to make a careful detailed survey of each bayou for a mile below its head, running level lines to determine the location of dams and levees. No levels were taken on this survey, and so short was the time at command that no work was done except that absolutely necessary.

The blue clay foundation can be depended on as it is, for there is no danger from its washing, but a good brush or plank apron will be necessary wherever any current very much greater than that at present found runs over the red soil. Much of this red-soil surface is now well protected by its growth of brush and trees.

Any improvement of this stream, to be of much benefit to the people of the valley above Washington, will require locks, and will be a slackwater navigation.

Natural conditions could not well be more favorable than they are. The banks are everywhere perfect from the point where the lowest lock of the series must be placed up to the mouth of the Lamourie, which is but a few miles from Alexandria. This channel, in the greatest floods, is never full, and, except the Lamourie and Huffpower, no bayous would require closing. Had the channel been dug for a canal it could hardly have been more uniform in cross-section.

There is sufficient water for needs of lockage at lowest stages, and if such dams are built and gates for locks made as can be removed when the water rises so high as to make them no longer useful, and replaced at will, as the stream falls, the slight amount of sediment deposited at low-water would be swept out at high-water.

In great floods much of the height above Washington is due to backwater. The lower one of this series of lock will need to be put at a point but few miles below Barry's Landing, as far up the bayou as there is sure to be sufficient water for navigation when depending entirely on backwater from the Atchafalaya at the lowest stage of that stream; this is found at the first place where the bank of blue clay is exposed on the seventeenth mile.

The discharge at the time of the survey was probably as little as it often is at extreme low river, and it was just above Washington 180 feet per second; several large bayous and 25 miles of river, with so large a cross-section that there was about the same current in it as would be the casein slack water navigation, intervened between this point and Little Devil Bar, which might be considered a lock, and how much, if any, water escaped at those bayous is not known, no current being perceptible in either bayous or lower river, yet the discharge over Little Devil Bar was 60 cubic feet per second. There had been at the time a long drought.

The conditions are almost exactly the same in the Courtableau, Bœuf, De Glaise, and in the Teche. So little is the difference that the same plan of improvement will answer for all of them.

The cost of the necessary dams and levees on the south bank of the Courtableau would probably come within $20,000, and perhaps much within it, but an exact estimate cannot be made from data procured. Cost of clearing the banks and removing snags above Washington will be about $200 per mile for the 90 miles, and if the locks and slackwater improvements are constructed the banks could be cleared for this amount. The same is necessary as well if navigation is to be improved for the high-water season alone. The 28 miles below Washington can be cleared of snags and overhanging trees for $50 per mile. This will make the total estimates for the Bœuf and Courtableau—

Clearing 90 miles above Washington, at $200	$18,000
Clearing 28 miles below Washington, at $50	1,400
Dams on Courtableau Bayous	20,000
Four locks and needle-dams, at $15,000	60,000
Add for contingencies 10 per cent	9,940
Total	109,340

This estimate is but $926.61 per mile, and, considering the probable amount of commerce per year, would be but a very low rate per ton. The bayou above Washington runs through some of the finest alluvial land in the State. There is also a large and

productive country to the westward of it, the products of which would find their way down what would, with this improvement, be practically a canal, penetrating nearly a hundred miles into a rich country which has heretofore had but a very uncertain and expensive outlet.

I have no data for the amount of commerce at present, but was told that an average of about three steamers per week passed between New Orleans and Washington each way through the year, and that were navigation uninterrupted its amount would be greatly increased,

Opening the navigation above Washington would be in fact more than doubling the area to be benefited by the entire system of improvements.

A chart of the bayou has been made on a scale of $\frac{1}{5000}$, giving topography, soundings, and obstructions.

Yours, respectfully,

H. C. COLLINS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF BAYOU DE GLAISE, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer H. S. Douglas, of an examination of Bayou De Glaise, Louisiana, provided for in act of Congress approved March 3, 1879.

Tracings of chart drawn to a scale of $\frac{1}{5000}$ will be forwarded in a separate package.

Recommendations of Mr. Douglas, as to plan of improvement, are given in his report and are concurred in. His estimates are also approved, the total amount of which, viz, $9,540, can be expended to advantage on the work during the ensuing fiscal year.

The commercial statistics furnished by Mr. Douglas show the work to be of very considerable importance. The work is not susceptible of permanent completion.

It is located in the collection district of New Orleans. The nearest light-house is at the entrance to Atchafalaya Bay.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

SIR: In obedience to instructions received from you, I left New Orleans October 21, 1879, for the purpose of making an examination of Bayou De Glaise, Louisiana, and have the honor to submit the following reports and accompanying charts:

My instructions were to run a transit and stadia line, with soundings, on the Bayou De Glaise, commencing at Simmsport, where the bayou debouches into the Atchafalaya River, and terminating at the town of Evergreen. This latter place, is not, however, on De Glaise, but on the Bayou Rouge, which is practically a continuation of De Glaise. These two bayous are formed by the waters of Red River, during high-water, flowing down through Bayous Lamourie, Choctaw, and du Lac into Lake Pearl, and from thence into Bayou De Glaise, one, if not the only one, of its outlets. After flowing down De Glaise $2\frac{1}{4}$ miles, the water arrives at what is known as the "Junction," or the point where Bayou Rouge leaves De Glaise—the water flowing either way from this point, one portion finding its way into the Atchafalaya by Bayou De Glaise, the other by Bayou Rouge.

The distance by both bayous from Simmsport to Evergreen is 63¾ miles, Bayou De Glaise 48 miles, and Bayou Rouge 15¾ miles. The average width of the former is 250 feet, that of the latter 175 feet. The general cross-section is like that of an artificial cut or canal. At the time of making the survey there had been a prolonged drought in the immediate country, and also very low-water in the Mississippi and Red rivers, in consequence of which the bayou was almost dry, the only water being a narrow stream or pool in the center, supplied from springs. This condition of affairs was highly favorable for the examination, as it enabled obstructions to be seen and noted that otherwise might have escaped observation. In lieu of soundings, which were unnecessary, the pools preserving an even depth, of 1 foot, cross-sections were made at intervals. These latter on the Bayou De Glaise show approximately the slope of the bed of the stream, as the general country, as well as the banks of the bayou, being all of alluvial formation, is nearly on a dead level. As is the case on all Louisiana bayous, the immediate banks are the highest land, the slope being from them toward the cypress swamps. The width of the cultivated land—that is, the distance between the bayou and the swamp—averages about one-half mile on the north bank and 1 mile on the south. It is a noticeable peculiarity that the south bank of all bayous has the widest strip of land to be cultivated, providing that the largest part of material during high-water is deposited on the south bank. The country bordering both bayous is thickly settled and all under cultivation, the principal crops raised being sugar, cotton, and corn.

The town of Evergreen is situated at the junction of Bayous Rouge and Huffpower. This latter connects the Bœuf and Rouge at high-water. Bayou Rouge continues on past Evergreen to the south, and finally meets the Atchafalaya at Churchville, where it has been closed by a dam, so as to obtain slackwater navigation in the lower bayou.

The obstructions noted on the chart in the first and second miles of Bayou Rouge consist of 29 standing trees, 1 fallen tree, and 19 logs.

From the third to the sixth mile the bayou makes a long bend, the distance across the point being about 1,800 feet. This bend is very badly obstructed by willows and other trees, which have grown up in the bed of the stream. At some past date this bend must have been cleaned out, as for a distance of 4,000 feet the fifth mile is filled with old stumps cut off to an even height of 2 feet above the bottom of the bayou. In this bend there are also numerous logs or fallen trees, besides two shoals or bars on the sixth mile; one 1,300 and the other 2,000 feet in length, and both from 1 to 2 feet above the general level of the bottom.

On the seventh, eighth, and ninth miles, the obstructions are 11 standing trees, 16 logs, 1 fallen tree, and three bars, one on each mile, respectively 500, 1,400, and 200 feet in length, and from 1 to 2 feet above the general level of the bottom of the bayou.

The tenth, eleventh, and twelfth miles are around Coco's Bend. For 8,300 feet the bayou is filled with standing trees, principally willows. Two fallen trees and about 30 logs would have to be removed. On the thirteenth and fourteenth miles, a shoal 2,500 feet long and from 1 to 3 feet above the general level of the bottom is to be found: also 6 logs and 15 standing trees.

In the fifteenth mile is the town of Cottonport. The bed of the bayou was perfectly dry from here to what is known as the "Junction" at the time of the survey. On the sixteenth mile there are six standing trees, and the last 1,000 feet is filled with the same. This also brings us to the "Junction" of Bayous Rouge and De Glaise. The bed of the Rouge at the "junction" is from 4 to 6 feet above that of De Glaise. From the seventeenth to the fiftieth mile Bayou De Glaise is almost clear. The obstructions to be found are all located on the chart, and consist of 12 fallen trees and 171 logs lying on the bottom.

On the twenty-fifth mile is the town of Moreauville, situated at the upper end of the cut-off road across the big bend; the town at the lower end is known as Hamburg. The distance by the bayou between the two towns is 30 miles, and by the cut-off road but 3½.

On the fifty-first mile will be found one of the three bad obstructions which exist on the bayou. It is a collection of logs on the bottom in the shape of a sunken raft. This seriously obstructs navigation, as it requires 2 feet more water to carry a boat over this raft than would ordinarily be required for the navigation of the bayou in that vicinity. One fallen tree would have to be removed.

Two fallen trees and one log are all the obstructions on the fifty-second and fifty-third miles. In the fifty-fourth mile is Mill Bayou, the mouth of which has been closed by an automatic gate, which only allows the water to flow into and not out from De Glaise. The obstructions are a sunken flat-boat and 1,200 running feet to be cleared of brush and standing trees.

The fifty-fifth mile is clear. The town of Hamburg is situated about the middle of this mile. The fifty-sixth mile has the north bank lined with brush and standing trees. On the fifth-sixth mile is the wreck of a sunken boat, which, however, is not bad, as it is partially broken up; also brush on both banks and one fallen tree. Fifty-seventh mile has brush on both banks to clear off. Fifty-eighth mile has 2,500 feet lined with

brush, one fallen tree, and two logs. On the sixtieth mile there is another raft, similar to that on the fifty-first mile, and to which the same remarks will apply, except as to length, this one being 500 feet in length; also, 3,200 feet to clear of brush. On the sixty-first mile is the last of the sunken rafts, this one being 100 feet long and similar to the others. One fallen tree and two logs to be removed; trees and brush to clear off.

The sixty-second, sixty-third, and sixty-fourth miles of the bayou are obstructed by brush and trees, growing into the channel; there being one particularly bad place at the beginning of the sixty-second mile, just below Yellow Bayou, where there is an island. Steamboat-men complain of this place as being hard to pass on account of projecting trees. Seven logs and one fallen tree have to be removed in this distance. Sixty-three miles and 4,500 feet bring us to the mouth of Bayou De Glaise, at the Atchafalaya River.

The rafts on the fifty-first, sixtieth, and sixty-first miles were placed there during the war to prevent gun-boats going up the bayou. It will not be necessary to clear the entire bed of the stream from brush, but only where it encroaches upon the channel. The best time to remove the obstructions would be between the months of July and February at low-water.

ESTIMATE FOR IMPROVING BAYOU ROUGE FROM EVERGREEN TO THE JUNCTION, 15¾ MILES.

Clearing channel from standing trees, stumps, logs, and fallen trees, 15¾ miles, at $200 per mile	$3,150 00
Add 20 per cent. for contingencies	630 00
Total	3,780 00

No estimate is made for removing the bars in Bayou Rouge, as the benefit obtained would scarcely justify the expense. They are only obstructions on the first stage of a rising or the last of a falling bayou. No boat has been in the Bayou Rouge since 1874, and in that year only a little beyond Cottonport. None have ever, so far as I could learn, gone to Evergreen.

ESTIMATE FOR IMPROVING BAYOU DE GLAISE FROM THE JUNCTION TO THE ATCHAFALAYA RIVER, 48 MILES.

Clearing brush off banks where it encroaches on channel, removing sunken logs and fallen trees, 48 miles, at $100 per mile	$4,800 00
Add 20 per cent. for contingencies	960 00
Total	5,760 00

There is a very valuable commerce to be benefited, as the bayou traverses a thickly-settled and productive country. All the land on both banks is under cultivation, the average crop being:

20,000 bales cotton, valued at	$750,000 00
1,653 hogsheads sugar, valued at	140,000 00
2,532 barrels molasses, valued at	30,000 00
	920,000 00

The miscellaneous country produce, in the way of corn, rice, stock, poultry, eggs, together with a considerable quantity of cypress lumber, will raise the value of the annual products to over $1,000,000. The value of return freights will also be considerable, as very nearly all supplies are brought from New Orleans. During low-water in the bayou all this business has been transacted by wagons, the charges for hauling cotton to Simmsport, the only shipping point, averaging $1 per bale, and is proportionate upon other articles. This tax is entirely avoided when boats come into the bayou, as they carry freight from the planter's landing to New Orleans for the same rate that it is carried from Simmsport. The removal of the obstructions mentioned is not, however, the improvement which the inhabitants most desire, for their removal will only improve the navigation for three or four months in the year—the months of March, April, May, and June—or during high-water in the Mississippi and Red rivers. What is most desirable is some improvement that will give them constant navigation. This can only be accomplished by means of slackwater, and Bayou De Glaise is singularly favored in its position in regard to such an improvement. Lake Pearl, its source, is 3¾ miles long by 2½ miles wide, and from 4 to 6 feet deep, surrounded by a cypress swamp, by the overflow of which its reservoir capacity could be greatly increased without injury to the neighboring country. The fall from the Junction, the highest

point to which it would be desirable to improve the bayou, to the Atchafalaya is, approximately, 22 feet, and the natural cross-section is the one that gives the minimum of evaporative surface, so that there would be but little loss from this cause. The data obtained from a mere examination is not, however, sufficient to predicate an improvement of this nature upon, though the country and commerce to be benefited would justify such a work. The inhabitants were particularly hospitable, and every kindness and attention was shown your assistant and his party during the examination.

Very respectfully,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF BAYOU TERREBONNE, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer W. H. Hoffman of an examination of Bayou Terrebonne, Louisiana, provided for in act of Congress approved March 3, 1879.

Tracings of chart, drawn to a scale of $\frac{1}{5000}$, will be forwarded in a separate package.

Recommendations of Mr. Hoffman as to plan of improvement are given in his report and are concurred in. His estimates are also approved, and can be expended to advantage on the work during the ensuing fiscal year, viz, $18,800. I am unable to furnish any commercial statistics other than those given by Mr. Hoffman in his report. The work is not susceptible of permanent completion.

It is located in the collection district of New Orleans. The nearest light-house is near east end of Timbalier Island, Louisiana.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF W. H. HOFFMAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER'S OFFICE,
New Orleans, La., January 31, 1880.

MAJOR: I have the honor to submit the following report on an examination of Bayou Terrebonne, Louisiana:

Field work was commenced on the 19th of August and completed the same month.

A transit line was carried down the Bayou from Houma, using needle for bearing and stadia-rod for distances; soundings and topography were taken, and all information possible had from the inhabitants, who did all in their power to assist in furtherance of the work.

Bayou Terrebonne was once an outlet bayou of the Mississippi, receiving its supply from Bayou Lafourche at Thibodeauxville, but the connection with Lafourche was long ago closed, and above Houma it is but a very small drainage bayou, useless for any purpose of navigation. Below Houma it is a tidal bayou, and serves the purpose of a highway, for which reason it is of great importance. For 20 miles it is bordered with large sugar plantations, and 6 miles farther by small farms. There are connected with Bayou Terrebonne many other bayous which depend on the navigation of the Terrebonne for their communication with a market. Roads on the bayou banks are entirely useless for moving freight.

There is now a railroad connection from Houma with Morgan's Louisiana and Texas Railroad; most freight goes that way. There are two steamers used for bringing

freights from plantations on Terrebonne and other connecting bayous to Houma for shipment by rail, but there is a canal in progress which, when completed, will connect the Terrebonne with Lafourche.

At Houma the width of the bayou is 40 feet and its depth at low-tide is 4 feet, but at intervals for the first 5 miles are shoals where but 2 feet can be carried over at low tide. All navigation at the upper end of the bayou near Houma is done at high tide, which gives from 1 to 2 feet more water, depending on the wind in the bays below. Much of the freight is carried by schooners which run to New Orleans through the lower bays and other connecting bayous, and by flat-boats which are cordelled and poled from plantations up to Houma.

With the 6 miles from Houma the water deepens to 4 feet at low tide, gradually deepening to 6 feet at the tenth mile, and varying from 6 to 8 feet to the middle of the twenty-third mile, but the width increases very rapidly after the twenty-first mile to 200 feet or more.

The right bank for the first 20 miles has a belt 50 feet wide of willows growing from the water's edge to the high land, while the opposite left bank has no willows, but has a belt of sea marsh grass to about the same width between the channel and the road which runs on the edge of the high land.

On the twenty-second mile is a canal, Madison Bellanger, and entered from the east, but it has been closed, and water stands on the back side of the levee 2 feet above water in the Terrebonne.

At the beginning of the twenty-fifth mile Bayou Lacache enters from the west; it forms the connection with Little Caillou Bayou, and all the commerce of that bayou, which is equal to that of the Terrebonne, comes through it and goes to Houma. It is timbered on both sides, and its depth is 5 feet or more.

For nearly a mile below Bayou Lacache the banks of the Terrebonne are above overflow, and are very thickly settled; but, from here to the middle of the thirty-third mile, where Bayou Lagraise enters from the west and connects with Terrebonne Bay, both banks are overflowed at high tide and not cultivated.

Opposite the mouth of Bayou Lagraise a canal has been dug through the bank to Lake Barré. It is 50 feet wide, 4 feet deep, and 300 feet long; it is expected that it will be finished through to Lafourche within a year.

The survey was continued down 5 miles farther, but for a mile below Bayou Lagraise there is a bar with but 2 feet depth, and no commerce passes down the old bayou.

No line was run below the twenty-seventh mile, as the bayou banks which were but very narrow strips of sea marsh between Timbalier and Terrebonne Bays, between which Terrebonne Bayou ran in 1850, and which is said to have had a greater depth than that found above at that time, are now broken up by the sea, from both bays, into little isolated grass islands, which are rapidly disappearing by action of the waves, and are now found at intervals of two or three miles down to Caillou Island, where was formerly the mouth of Bayou Terrebonne.

The old channel is filled so as to be, like the bays on each side, but a sand or mud flat with no appearance of there ever having been a bayou there. Cutting off the supply of water from the Mississippi stopped also the supply of mud by which the banks were built up. The improvements needed on this bayou consist of cutting overhanging trees on the right bank for 20 miles below Houma, and of dredging the first 5 miles so as to give as much water as there is below, or at least to give enough for the passage of boats. Dredging to a depth of 4 feet at least, at low tide, will give a high-water channel sufficient for all purposes at present. This would make an estimated cost for the improvement as follows:

58,666 cubic yards dredging, at 25 cents	$14,666 67
20 miles clearing, at $50 per mile	1,000 00
	15,666 67
Add for contingencies, 20 per cent	3,134 33
Total	18,800 00

The commerce to be benefited includes the whole amount coming to the town of Houma by water, up the bayou, which was in 1878-'79, 14,175 hogsheads sugar; 20,840 barrels molasses; there was also much rice and other produce, but sugar plantations furnish a greater part of the freight.

Very respectfully, your obedient servant,

W. H. HOFFMAN,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF TCHEFUNCTE RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer W. H. Hoffman of an examination of Tchefuncte River, Louisiana, provided for in act of Congress approved March 3, 1879.

Tracing of chart, drawn to a scale of $\frac{1}{5000}$, will be forwarded in a separate package.

Recommendations of Mr. Hoffman as to plan of improvement are set forth in his report and are concurred in. His estimates are also approved and can be expended to advantage on the work during the ensuing fiscal year, viz, $5,460.

I am unable to furnish valuable information concerning the commercial importance of the work. It is not susceptible of permanent completion.

The nearest light-house is on the Tchefuncte River, near Madisonville, La.

Mr. Hoffman was also directed to make an examination of Bayou Castain, which the citizens of Mandeville, La., solicited me to have made with a view to its improvement by the general government, that it might serve as a harbor of refuge for vessels plying on Lake Pontchartrain. The result of the examination is appended to Mr. Hoffman's report on the Tchefuncte, and his recommendations as to plan of improvement of Bayou Castain and estimates are approved.

The amount, $3,410, can be expended to advantage on the work during the ensuing fiscal year.

The collection district and nearest light-house are the same as for the Tchefuncte River.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. H. HOFFMAN, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: I have the honor of submitting to you the following report on the examination of the Tchefuncte River, Louisiana.

A survey of this river was made in 1871, by the late Lieut. E. A. Woodruff, United States Engineers, and a tracing of the chart made by him was used on which to note all changes which have taken place since that time. Cross-sections were taken at the most important points, following lines of soundings made by Lieutenant Woodruff nearly as possible. Covington is at the head of navigation on the Bogue Falaya, which is only navigable for small schooners to this point, steamers stopping at Covington Landing, 2 miles below. There are many snags and overhanging trees on the portion of river between the steamboat landing and Covington, and the channel is very crooked; bends are very sharp; banks are of sharp sand and almost constantly changing in freshets. Many bars are found with too little water to allow larger vessels to pass than the small schooners at present found. No other improvement than removal of snags and overhanging trees is advisable, as cut-offs, which captains of schooners so much wish, would only result in increasing the caving of the bank and would probably injure the river below, where it is now good. Below the mouth of the Abita, the bank has a gentle slope towards the river, and is nowhere caving; there is a wide, deep channel, fully sufficient for any possible want of navigation. The banks on the lower part of the river are sea marsh, covered at high tide. The entrance of the river into Lake Pontchartrain has a bar on which is found but 5¼ feet at a common low tide. During northers there is fully 1 foot less, and at such times

the harbor is most needed as a harbor of refuge for vessels from all coast ports as far east as Pensacola, coming into Lake Pontchartrain during a norther.

The entrance to New Orleans basin canals, on the lake, is a very difficult one, and very dangerous indeed with a norther blowing. The chief business of the steamers running in this trade is carrying passengers to and from the sea-side watering-places, and for them some safe harbor on the north side of the lake is very important. The harbor to which improvement of this bar would give these access is one of the best possible for such purposes. The river is several hundred feet wide and 20 to 30 feet deep, for 2 miles, up to Madisonville, where steamers can tie up at the bank at any time. The bar is made of sand and shell washed from the lake and not from material carried out by the river, which is a clear-water stream. The constant progress of the point and the bar to the southwest, and the washing away of the west side by the current, shows that the bar is the effect of the washing of the sand of the lake beach to westward along the coast. The winds affecting this shore blow from southeast, and a jetty to protect the entrance from this wash of sand from eastward may be found necessary to retain the channel, even if one should be dredged out, as can be easily done.

Estimate for the improvements is as follows:

Removal of all snags to Covington	$300
Removal of all overhanging trees	500
Dredging on bar 15,000 cubic yards, at 25 cents	3,750
Add for engineering and contingencies, 20 per cent	910
Total	5,460

At the urgent solicitation of the citizens of Mandeville, an examination was made of Bayou Castain, the mouth of which was formerly their harbor, on Lake Pontchartrain, but its entrance from the lake is now so filled as to be useless. The bayou drains about 10,000 acres of timbered land, and during rains there is sufficient current to wash out the sand from the entrance and give a channel across the bar at times as deep as 4 feet, but unfortunately, with the first blow from the southeast it is filled with sand; seldom remaining open for a week, and filling so as to leave but ½ a foot of water over the sand. This washing-out process gave the idea of making a permanent entrance, and a charter was secured from the State; cribs were made and slightly ballasted with brick, placed on each side of the entrance. A few of these cribs remain, and as far out as they go the channel remains, but most of the cribs washed ashore, and the work was abandoned from want of money for continuing it. The success of this crib work, so far as it went, shows that a jetty properly built would keep the sand from filling the channel, the filling all being made by sand washed along shore to westward. There is a depth of 6 to 7 feet in the bayou, and were the entrance so improved as to give a depth of 5 or 6 feet on the bar, the commerce of the town would be greatly benefited, and the harbor thus made would be available as a harbor of refuge on this (north) shore during the gales of the fall and winter months.

Mandeville is one of the coast watering-places and during the summer and fall from one to three steamers stop there every day, and one daily during the remainder of the year. There are also many schooners.

The estimated cost for the improvement to be made is as follows:

12,400 cubic yards dredging, at 25 cents	$3,100
Add 10 per cent. for contingencies	310
Total	3,410

Yours, respectfully,

W. H. HOFFMAN,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF TICKFAW RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer H. C. Collins of an examination of Tickfaw River, Louisiana, made by Civil Assistant H. S. Douglas, as provided for in act of Congress approved March 3, 1879.

Tracings of chart, drawn to a scale of $\frac{1}{5000}$, will be forwarded in a separate package.

Recommendations of Mr. Collins as to plan of improvement are set forth in his report and are concurred in. His estimates are also approved; the total amount of which can be expended to advantage on the work during the ensuing fiscal year, viz, $10,230.

The commercial importance of the work is given in the report of Mr. Collins.

The work is not susceptible of permanent completion.

It is located in the collection district of New Orleans. The nearest light-house is at the mouth of Pass Manchac, Lake Pontchartrain.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: I have the honor to submit the following report of the examination of Tickfaw River and its navigable branches. The Tickfaw River rises in the State of Mississippi and empties into Lake Maurepas. North of the beginning of this survey the river is at low-water but a succession of pools, connected by ripples, over which in long droughts but little water flows, and its banks are high rolling pine woods land, or a bottom once washed out by the stream and heavily timbered, covered in freshets by the river.

The survey was made by H. S. Douglas, assistant engineer. He began at the crossing of the Baton Rouge and Ponchatoula road, where the stream is 60 to 80 feet wide and 5 to 10 feet deep at low-water; but there are bars where but 3 feet is found. The first 6 miles, above Mr. Chapman's place, is so choked by old logs, snags, and trees down in by the gale of September last, as to be almost impassable even for a skiff, and there is an almost continuous line of overhanging trees on one side or the other. On the fourth mile from the beginning is Whetmore Island, where the river divides; one part passing to the west of the island, having at its head much the largest cross-section, is entirely blocked by raft of snags, trees, and drift, and the other part, passing to eastward of the island for nearly a mile, is but 2 feet deep and less than 30 feet wide in places, and much obstructed by timber standing and fallen. This island and its two obstructed channels are probably the dam which makes the 4-mile pool above, and at low-water any improvement of these channels will probably draw off the water above; but below the island the character of the river changes to a tidal stream, with a current depending entirely on the tide, except at freshets.

From Chapman's place to Mr. Settoon's place is 4 miles, and, though the depth is nowhere less than 4 feet and the width great enough, so that schooners or steamers could easily navigate it, they are entirely prevented by the great number of logs and the overhanging trees. Mr. Chapman made one cut-off many years ago, and attempted to make another one, but failed to turn the river through the second, and it can yet be easily closed and saves half a mile of river and 4 bends of 240° or more each, while this cut would give a long, straight reach. The first cut-off which he succeeded in making was an unimportant one, shortening the river so little as not to appreciably change the slope, and these, so far as could be learned, were the only attempts to interfere with the river. The banks are nowhere caving, and once cleared the channel would probably remain good. The bottom land is so low that it is covered with every freshet, and is not liable to be cleared so as to form cut-offs; a growth of cane protects it from washing. The water is almost absolutely free from any earthly material in suspension, but is colored to a dark coffee-color by cypress and gum. Mr. Settoon's place is now the head of navigation for schooners, which they find great difficulty in reaching, from the great number of trees blown in by the September gale. There were many old snags and some overhanging trees forming obstructions before. Below this there is nowhere less than 9 feet depth in the channel; 8 miles below Settoon's, Blood River enters from the north; it is but a tidal stream so far up as it is navigable (about 4 miles), and the width is 80 feet or more and the depth about 10 feet. There are many old snags and trees and some overhanging trees. Bluffs touch the river sufficiently often to afford landing places. From the mouth of Blood River to the Natalbany is 6 miles, and from thence to Lake Maurepas is 2 miles. This distance has a channel fully 250 feet wide and a depth of 10 to 20 feet. The Natalbany enters from the north

and is navigable to the town of Springfield, 10 miles above its junction with the Tickfaw. The depth is nowhere less than 10 feet in the channel, and it has a sufficient width to turn a schooner or steamer almost anywhere, but it is somewhat obstructed by snags, trees, and overhanging trees. The Ponchatoula River is the most easterly branch, and enters the Natalbany 4 miles above its junction with the Tickfaw. Except during freshets it is entirely supplied by tide-water, and rises and falls with the lake.

The survey of it began at the bridge on the Baton Rouge and Ponchatoula road, to which point there is sufficient width ad depth for navigation, but the first 2 miles is much obstructed by overhanging trees and by logs and trees in the water. Below Wadesborough there is now navigation for schooners, but the channel is much obstructed by overhanging trees, by trees blown in during the gale of September, and by old logs and snags. Each of the three branches of the Tickfaw is of more commercial importance than the main stream, and removal of the obstructions will facilitate communication with New Orleans, and make it possible to use steamboats instead of schooners. Any increase in regularity and speed of the means of communication will promote settlement of the country and increase its commerce. The schooners now coming to these rivers during all the year (except the three or four dull months of summer) are about as follows:

	Schooners per week.
To the Natalbany	4
To the Ponchatoula	3
To the Blood River	2
To the Tickfaw	3

Besides the freight of these schooners, great quantities of hewn timber, spars, and saw-logs are floated out, and are to be included in the commerce of these rivers.

The depth of water, which depends entirely on the height of water in Lake Maurepas, is never so little as in the least to affect navigation, and there is at lowest water of a winter norther 7 feet of water over the bar at the mouth of the Tickfaw in the lake, but the bar at the mouth of Pass Manchac in Lake Pontchartrain has but 6 feet depth, and at low-tide, with a northwest wind, less than 5 feet. The entire commerce of these rivers, and the Amite and other rivers entering Lake Maurepas, must all pass this bar. No survey has been made of it, but from information given by captains of vessels passing there, I think it will require about 20,000 cubic yards of dredging to make a good channel. The available depth is said to be much less than it was previous to the breaking of the Bonnet Carré crevasse in 1874. Most of the water from that source now finds its way into Lake Maurepas, and from it alone comes the mud for a bar at the mouth of Pass Manchac, as all the rivers entering the lake are clear-water streams. The cost of dredging the 20,000 cubic yards will be about 25 cents per yard, or $5,000 for the whole, if the information should prove correct as to its amount, and if nothing but dredging were required.

On the banks of the Tickfaw and each of its branches are many shell mounds which are kitchen refuse of some ancient race. The shells of these mounds are mostly the gnathodon clam, which is now found living in the lake below, and throughout the mounds are pieces of broken pottery and bones in small amount compared with the shells; but all bones of any size show marks of having been cooked and of having been split to get at the marrow. They are part animal—deer, &c.—and in part human bones. The mounds are like those found on all other rivers on this part of the coast. These shells would be of value if works were made to improve Lake Pontchartrain navigation. The improvement of the Tickfaw River far above the head of the present survey would open a country where are growing great forests of yellow pine, and afford means of floating it out; far less work would be necessary for this than for any purposes of navigation. In its present condition the upper river, even in highest water, cannot be used for rafting. From the head of the survey down to the Chapman place, closure of one fork at Whetmore Island, and removal of the snags and trees now, may give the water of the next one or two high river seasons a chance to wash out one channel to an extent to make it navigable. It is quite probable that a little washing on the shoal places will show that they are really but sunken logs slightly covered with sand; and, if so, removal will at once make the river navigable to the head of the survey. Estimates for the improvements proposed will be as follows:

Tickfaw River from head of survey at Van Buren place to Chapman's place, 6 miles, at $500	$3,000
Chapman's to Settoon's place, 4 miles, at $300	1,200
Settoon's to lake, 16 miles, at $100	1,600
Blood River, 4 miles, at $100	400
Natalbany and Ponchatoula rivers, 15½ miles, at $150	2,325
Add for contingencies, &c., 20 per cent	1,705
Total	10,230

A chart of these rivers has been made on a scale of $\frac{1}{10000}$, showing all visible obstructions and character of the banks, soundings at low-water, &c.

Yours, respectfully,

H. C. COLLINS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION OF AMITE RIVER, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer H. S. Douglas of an examination of Amite River, Louisiana, provided for in act of Congress approved March 3, 1879.

Tracings of chart, drawn to a scale of $\frac{1}{5000}$, will be forwarded in a separate package.

Recommendations of Mr. Douglas as to plan of improvement are given in his report, and are concurred in. His estimates are also approved, and can be expended to advantage on the work during the ensuing fiscal year, viz, $23,760.

I am unable to furnish valuable information concerning the commercial importance of the work other than that given in the report of Mr. Douglas. The work is not susceptible of permanent completion.

It is located in the collection district of New Orleans. The nearest light-house is at the mouth of Pass Manchac, between Lakes Maurepas and Pontchartrain.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. S. DOUGLAS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

SIR: In obedience to instructions received from you, I left New Orleans August 18, 1879, for the purpose of making an examination of the Amite River, Louisiana, and have the honor to submit this my final report, with accompanying charts.

The river was traversed with transit and stadia, and soundings taken for 73¼ miles, commencing at Thompson's Bridge, where the road from Clinton to Amite City crosses the river, and ending at the point where Bayou Manchac joins the Amite. Below that point a running examination was made, as per orders.

The Amite, or old river Bienville, below Bayou Manchac, had been previously surveyed in the year 1867, by Lieut. J. K. Hezlep, United States Engineers. (See Report of the Chief of Engineers for 1868, page 486.)

For convenience in description I divide the river into three sections in reference to the cost and difficulty of improving the same. All obstructions are delineated on the accompanying charts, and a minute description of the same, mile by mile, would be tedious.

FIRST SECTION

comprises the distance from Thompson's Bridge to the end of the fortieth mile, and will all be found on chart No. 1.

The river meanders through a heavily timbered valley or bottom land which averages about 1 mile in width, and subject to overflow during floods. The margin of this valley and the high-water banks of the river is a high rolling country, thickly settled and well cultivated. In its meanderings the river occasionally strikes this high country, and in such cases the bluff averages from 20 to 30 feet in height.

Timber of almost every variety abounds in the valley, cypress, pine, and beech be-

ing the most prevalent, but owing to the numerous obstructions in the stream it is never rafted to a market.

The obstructions are chiefly trees, which have fallen in by the caving of the banks, caused by the swift current during floods. The general character of the stream is a succession of pools, sometimes over a mile in length and not less than 4 feet in depth, connected by ripples or shoals, there often being not more than 1 foot of water over them. The bed of the stream is generally gravel or sand, and the shoals are invariably composed of these materials.

There are a number of island chutes which would require to be closed, as the river during low-water cannot bear any diversion of its volume from the main channel. But few cut-offs exist, and those that do have been made by the river itself and not by artificial means. The average width of this section is 100 feet, with a least depth of 1 foot; maximum velocity of current at high-water, 4.4 feet per second; average velocity at low-water, 1.4 foot per second. The obstructions to be found consist of about 450 snags, 300 fallen trees, 200 overhanging trees, and 20 standing trees. The removal of these, together with the closure of 19 island chutes, and clearing out of two cut-offs, would give a low-water channel of 20 inches. One bridge would have to be converted into a draw or removed.

The removal of these obstructions would cost $300 per mile, making a total for the 40 miles of $12,000.

SECTION NO. 2

includes from the fortieth mile to the junction of Bayou Manchac, 73½ miles from the initial point of the survey, comprising 33½ miles of river. The valley of the river is the same as that of the first section, but the width and depth of the stream are greatly increased. On the forty-first mile it receives from the west its first tributary of any size, Sandy Creek, and on the fifty-sixth mile it is joined by the Comite, a stream of about one-half the volume of the Amite. The addition of these two streams increases the average width to 175 feet. The present least depth below Sandy Creek is 2 feet, and below the Comite 3 feet. There are no ripples, and the velocity of the current is decreased, the fall being divided over the entire distance instead of being concentrated at the ripples or shoals. The maximum velocity is 2.2 feet per second, minimum 0.4 foot per second. The obstructions to be removed consist of about 175 snags, 140 fallen, 100 overhanging, and 35 standing trees; also about 10,000 running feet of bank to be cleared of projecting willows. There are three island chutes to be closed, three cut-offs to be cleared out, and one bridge to be removed or converted into a draw. The removal of these obstructions would give a low-water channel of 3 feet.

The amount required is estimated at $150 per mile, making a total for the 33½ miles of $5,025.

SECTION NO. 3

comprises from Bayou Manchac to Lake Maurepas, 37 miles, is a tide-water bayou, with ample depth for all vessels navigating it. Before the closure of Bayou Manchac, this bayou, together with the Lower Amite, formed one of the many passes through which the waters of the Mississippi found their way to the Gulf, and was then known as the river Bienville. There is at the present time a line of steamers running between New Orleans and Hope Villa, on Bayou Manchac. The chief obstructions complained of by these boats are the bars at the mouth of the Manchac and at the mouth of the Amite in Lake Maurepas, but as no line was run upon this portion of the stream, there is not sufficient data to base an estimate for their improvement upon. Any improvement of these bars would necessitate the same upon the one at the Lake Pontchartrain end of Pass Manchac, as the depth of water upon all three is about the same, varying from 5 to 6 feet at low-water, the least depth being during the prevalence of northwest winds.

Four and a half miles below Manchac is the town of Port Vincent, and from here to Whitehall, 16 miles below, the banks are quite thickly settled; this portion of the river having the immediate banks the highest and sloping back to the swamp. From Whitehall to the lake the banks are swamp, with an occasional shell bank. The obstructions consist of 45 snags, 26 fallen and 42 overhanging trees. There is nowhere in the river less than 15 feet of water, and, except during floods, the current depends upon the tide.

An estimate of $75 per mile is made for this section, making the total amount for the 37 miles $2,775.

RECAPITULATION.

First section, 40 miles, at $300 per mile	$12,000
Second section, 33½ miles, at $175 per mile	5,025
Third section, 37 miles, at $75 per mile	2,775
Add 20 per cent. for engineering, contingencies, &c	3,960
Total	23,760

The commerce to be benefited is large and important, as the river is bordered by plantations, the most of which are engaged in the cultivation of cotton. Should the upper river be opened to navigation, at least 10,000 bales of cotton, besides considerable sugar, corn, and all varieties of country produce, together with lumber and wood, would find their way by this route to a market. At present all produce has to be hauled overland, either to the Mississippi River or Jackson Railroad.

Staves, shingles, lumber, and wood are the principal products of the lower river, and a considerable quantity of sugar and molasses comes from Bayou Manchac. The return trade would be large, as all persons residing on the river would obtain their supplies by this route. The present value of the commerce of that portion of the river navigated is about $250,000 per annum.

The Amite River is the natural drain of all the country lying between it and the Mississippi River, and its headwaters extend far up into the State of Mississippi. The bed of the stream is not sufficient during heavy rains to carry off the drainage of this immense area, and, in consequence, it overflows its entire valley, sometimes rising 15 to 18 feet in 24 hours, this being its range between high and low water at Williams's Bridge.

Your assistant was informed that in years past the subject of improving this river had been agitated, and that the State government had appropriated $75,000 for that purpose. With this appropriation the river was cleared of obstructions as far up as Dennis's Mill, 22 miles below the initial point of the present survey.

All the inhabitants take a deep interest in the proposed improvement, and your assistant and his party were treated with the utmost hospitality, and every assistance required cheerfully afforded.

Very respectfully,

H. S. DOUGLAS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

EXAMINATION FOR A CANAL TO CONNECT THE WATERS OF BAYOU TECHE, AT CHARENTON, WITH GRAND LAKE, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith the report of Assistant Engineer H. C. Collins of an examination for a canal to connect the waters of Bayou Teche, at Charenton, with Grand Lake, Louisiana, provided for by joint resolution approved June 28, 1879.

A plot showing the location of the proposed canal, and profiles, drawn to a scale of $\frac{1}{2500}$, will be forwarded in a separate package.

Recommendations of Mr. Collins as to plan of improvement are concurred in. These will be found in his report, appended hereto. His estimates are also approved, and can be expended to advantage on the work during the ensuing fiscal year, viz, $73,196.40.

The work will constitute a permanent improvement, in the ordinary acceptance of the word permanent. The work is of very considerable importance, as set forth in Mr. Collins's report.

The work is situated in the collection district of New Orleans. The nearest lighthouse is at the mouth of the Atchafalaya River.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: I have the honor to submit the following report of the examination for a canal at Charenton, to connect the waters of Bayou Teche at Charenton with Grand Lake, Louisiana.

I arrived at Charenton on the 22d of November, and found Mr. Edward Sillon, E. Maynard, and Alfred Fusilier, the parish surveyor, who gave me all necessary information about land lines and high and low water marks, and, with other citizens, gave all the assistance needed in measuring distances and running the level lines. All were very much interested in the proposed improvement.

The actual distance from water edge in the lake to Bayou Teche is 5,594 feet at low-water, but for the canal 5 feet in depth at low-water 1,000 feet from shore line in the lake to the channel must be added to this distance. The land crossed is an old sugar plantation. All was once in cultivation, but is now, except a small field, abandoned to common pasture. It is entirely free from trees or stumps.

There is no swamp, and, though no borings were made, the universal experience along this portion of the Teche in digging wells for stock water, &c., would show that there is no quicksand to interfere with the excavation of the canal.

At the time of the survey the wind had blown for several days from the northwest, and the water was at the extreme low stage only reached at low river after northers.

In the Teche the water was 1.593 feet below a mean low-water mark established by Mr. Fusilier from the experience of many years on the bayou. In Grand Lake it was 2 feet below the black low-water line on piles and cypress trees in and near the water.

The depth in the lake, when the channel was reached, 1,000 feet from shore, was 4 feet, and soundings were made three-fourths of a mile further with no change of depth, and I was told that the depth was uniform entirely across the lake to Bayou Pigeon, but that it was deeper northward to the channels leading into the lake from the Upper Atchafalaya.

The bottom was blue mud, quite stiff, with many shells of gnathodon clam, both alive and dead; and the shore just eastward from the proposed mouth in the lake is a ridge, 15 feet high in places, of the same shells.

The plantation is known as the Mossy Tract and belongs to the Citizens' Bank of New Orleans. Mr. Sillon had communicated with its officers and had found them willing to grant the right of way free; which they could well afford to do, as it would give them a permanent levee on the upper line of the plantation.

The height of water in the Teche was 0.097 foot above that of the lake November 23, and at low-water there is seldom any material difference in the water levels.

The flood of 1874 was the highest known in Grand Lake, and its height was 12.776 feet above extreme low-water, reaching to within 500 feet of the water of the Teche, and the narrow ridge between them was here but 1.383 feet high. The water of the Teche at the same time was 2.889 feet below that of the lake, and, though the highest known in the Teche, was but 9.790 feet above extreme low-water. The low-water supply of the Teche is mainly by Bayou Fusilier and entirely from rains of the region to westward of the Teche. The waters of the Teche join those of Grand Lake at the junction of the Teche and Atchafalaya, but it is about 80 miles around by water from Charenton to the lake end of the proposed canal.

Directly across Grand Lake, about 9 miles, is the mouth of Bayou Pigeon, which forms a direct navigable connection with Grand River and through it with Plaquemines Bayou, and, if a lock should be made in this bayou so as to form a connection once more with the Mississippi River, this would be by far the nearest route for water communication between the Teche country and New Orleans. Before that time it would save about 75 miles over the present route and connect with it at Butte-a-La-Rose or below, avoiding the worst portion of the present channel, and having a low-water depth 1½ feet greater. There is a network of bayous between the Teche and the Mississippi River, all connecting with the Atchafalaya. Many of these bayous are now closed to navigation by blocks of raft. The navigable channels and those capable of being made so could only be known on a full careful survey of the entire Atchafalaya and its connecting bayous, which has never yet been made.

For this canal a cut 50 feet wide at the bottom will be sufficient for commerce, and banks with a slope of 1 to 1 will probably stand in that kind of soil.

A basin 600 feet long and 100 feet wide is proposed about the middle of this canal to give room for passing of boats and a place for them to lay up in case of necessity. The navigable depth of the route will be at mean low tide of ordinary low water 5 to 6 feet. As the cut requires to be carried out 1,000 feet into the lake, a breakwater may possibly be found necessary on the east side, which is the only one exposed to danger from storms.

This proposed canal is peculiar in one respect. At times of sudden rise in the Mississippi or break of its levees, Grand Lake in some extreme case may rise nearly 5 feet

higher than the water of the Teche. This extreme difference would last for but a few days, but a difference of nearly 2 feet would be a common case in time of high-water in Mississippi River. At low-water seasons a difference of 2 or 3 feet is at times found. This makes a lock necessary in the canal, and one with double gates, so that it can be used in either direction.

The amount of water for lockage would, in the nature of the case, be unlimited, so that two abutments, with the gates at a distance of 500 feet or more apart, would make a lock, the sides of which would need no other wall than the earth bank of the canal. The abutments carrying the gates would need to be long enough for the double pair of gates. The width of the clear passage should be 45 feet, and the gates would remain open at all times when the difference of level was so little as not to cause a scouring current. The excavated earth would form embankments far above all overflow. Estimate for the work would be:

183,988 cubic yards excavated, at 25 cents	$45,997 00
Gates and abutments, approximate	15,000 00
Add for contingencies 20 per cent	12,199 40
Total	73,196 40

The commerce to be benefited by the proposed canal is now annually 15,000 cypress trees, which have to be towed 80 miles farther than necessary, and 35 of which is over an open lake where rafts are frequently broken up and lost, at an extra expense of not less than $1 each. Five hundred thousand barrels of coal now used, at an extra expense of not less than 5 cents per barrel for towage and risk, probably much more than that. The entire amount of all the lumber now used on the Upper Teche, all of which comes from the Upper Grand Lake country and above, and all of the fencing, would also be saved that distance of towage, as it also comes from the swamp bayous of the Upper Atchafalaya region, passed the head of Grand Lake. The amount of these is not known, but is very great. Also, all the sugar and cotton raised in the Teche country, and that coming down it from farther west, would have a route shorter by 75 miles than at present, and a low-water depth 1¼ feet greater at least.

Commerce would be greatly increased as the lands of the bayou and those of the prairie country to westward were brought more fully into cultivation.

This canal, however, forms but a connecting link in the general plan for improvement of the bayous of the whole delta region. Although it alone would be of great benefit to the inhabitants of the Teche country, its value would be greatly increased if the work on the Teche, Atchafalaya, and its connections above with Red River and Courtableau, and the shortened route into the Mississippi by way of the Plaquemines Bayou were completed.

Plot and profile of the canal are made on scale of $\frac{1}{2500}$.

Yours, respectfully,

H. C. COLLINS.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

SUMMARY OF PRECEDING REPORTS ON EXAMINATIONS AND SURVEYS OF WATER COURSES IN LOUISIANA.

UNITED STATES ENGINEER OFFICE,
New Orleans, February 27, 1880.

GENERAL: I have the honor to submit herewith report of Assistant Engineer H. C. Collins on the various surveys and examinations recently made in Louisiana, under my direction, as provided for in the river and harbor act approved March 3, 1879. This report is a summary of the different reports of examinations and surveys, and a condensation of the plans and estimates submitted with a view to the general improvement of the water courses surveyed.

Very respectfully, your obedient servant,

C. W. HOWELL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. H. C. COLLINS, ASSISTANT ENGINEER.

NEW ORLEANS, LA., *January* 31, 1880.

MAJOR: The surveys on which Messrs. Douglas, Hoffman, Elms, and myself have been engaged since the last annual report can be divided by the Mississippi River into two parts.

The portion east of the Mississippi consists of examinations of the Pearl River, Mandeville Harbor, Tchefuncte River, Tangipahoa River, the Tickfaw and its bauches, Ponchatoula, Natalbany, and Blood, and the Amite rivers.

A large portion of the work required on these streams consists of removal of snags, logs, and trees from the channel, and overhanging trees from their banks, but includes some dredging at the entrances of Tchefuncte and the Bayou Castain at Mandeville.

Fuller data are necessary than could possibly be obtained for Pearl River before finally determining on the exact route for the new channel to follow. The distance to be examined and the time possible to spend upon it were so disproportionate that but one line could be followed. Should an appropriation be made for work on the lower portion of the river, a few weeks will be required for its further examination, not in regard to the possibility of improving it or the necessity of so doing, but only the details necessary for deciding on the route to be followed.

The importance and feasibility of the improvement were fully shown by the examination.

The harbor at Mandeville can easily be made, and such a harbor, besides accommodating the trade of the town, would frequently prove a safe harbor of refuge for shipping during the gales.

There is little work to be recommended for the Tchefuncte River. Some removal of snags and trees will be useful and is needed, but it is not practicable to much improve the river except at great expense, not warranted by the good to be derived, but an improvement of the bar where it enters Lake Pontchartrain, so that it will be possible to cross at any time, is very much needed, and will be but a slight expense compared with its importance as a harbor of refuge for the shipping on the lake, as well as for the vessels going into the river during the frequent gales.

The examination of Tangipahoa River, which was made last winter by Mr. Douglas too late for action by Congress at that time, showed that the expense of carrying navigation nearly 60 miles up that river would not be great, and that it would give a great relief to farmers in transportation of their produce and for manufacturers who have begun business on its banks.

The improvement of Tickfaw River and its tributaries, costing but little in all, would open an extensive and valuable country to commerce, and very much improve the facilities for that at present existing.

Mr. Douglas's survey of and report on the Amite River shows the importance of that stream to a large tract whose only outlet to market it is, and the great help which extension of the navigation about 60 miles above its present head would be to the inhabitants near it. The improvement of the rivers emptying into Lake Maurepas would lose much of its importance unless Pass Manchac, connecting Lake Maurepas with Lake Pontchartrain, should also be improved.

Although no survey of this pass was made, it was ascertained from parties considered reliable that the depth of water over the bar at the entrance of the pass into Lake Pontchartrain was only 5 feet at ordinary low-water, and during northers nearly a foot less. Five thousand dollars would probably increase the depth to the advantage of commerce through the pass.

The examinations west of the Mississippi River were on bayous of the delta of that river, where the present commerce is immense and constantly increasing.

One class of these bayous has lost the connection with the Mississippi which the other class yet retains, and must be treated in a different manner from those receiving their supply from the Mississippi.

Bayou Terrebonne is the only one examined belonging to this class. The entire class are now merely tide-bayous, and at their sea-ends the shoal bays are encroaching on the sea-marsh banks and tending to level down the little irregularities, not probably taking the 10-foot curve of the Gulf at all shoreward, but on the contrary advancing it, while washing away the narrow strips of sea-marsh near the outer ends of the bayous, which were always covered at high tides.

So long as the connection with the Mississippi remains open, as is the case with La Fourche, the bayou will retain its side walls of sea-marsh and gradually push them seaward, while waves of the Gulf pile up a portion of the material carried out as a chain of coast islands.

Between the mouths of La Fourche and Atchafalaya the whole delta front now appears to be undergoing this rounding-off and leveling process. There are many bayous included, all of which have lost their connection with their former source of supply in the Mississippi. Terrebonne and Timbalier bays have become practically but one bay by the disappearance of the narrow tongue of sea-marsh which divided

them in 1860, which was made and sustained only by additions received from the Mississippi through Bayou Terrebonne.

So far as Bayou Terrebonne and similar bayous are concerned, no help can be given them which will materially improve them, except some tide-water canal which should connect the whole region from the Mississippi west, dredging through the sea-marsh following the course of available bayou, bay, and lake channels to save dredging, opening in this way the entire seaboard to internal navigation to the Texas State line at least. The subject was noticed in the report on the inland water route in 1874.

Parts of this work are now being done by private enterprise on different charters from the State. There are several such canals that have been abandoned, and those that are kept open cost about as much for repairs as the receipts from tolls amount to.

The remainder of the bayous examined are those which connect with the Atchafalaya. The first of these is Bayou De Glaise, which enters the Atchafalaya at Simmsport, a few miles below its head. It is only for a few months of the year that there is any natural supply of water for open navigation of this bayou, and that comes from Red River or back-water from the Mississippi. Lake Pearl is its head. The lake and its adjoining low cypress swamps will, as a reservoir, hold a supply sufficient to last through any but protracted droughts for lockage of the low-water season.

Level-lines were not run on any of these examinations, but sufficient data were obtained from high-water marks and height reached by any given back-water to show that it will take but three locks, each of which would require a lift of 7 to 8 feet, to open this rich and productive country to commerce throughout the year.

The plan for needle-dams, with permanent supports for the needles and abutments for the gates about 200 feet apart, using the walls of the bayou as lock-walls, is applicable to this bayou. The plan is a modification of that so extensively in use in France, and is so changed as to fit the peculiar circumstances of these bayous. At high-water needles would be removed and gates opened, giving free passage 25 feet wide.

Evergreen village is 7 miles from what would be the head of permanent navigation with these improvements; it is situated on "The Bay Hills." Valleys are cut through this high land, the one between Avoyelles Prairie and Bay Hills being occupied by the De Glaise and Bayou Rouge, a connecting bayou, which, during very high water takes some of the water from Bayou De Glaise, 2 miles below Lake Pearl. Bayou Rouge is joined by Bayou Huffpower from the Bœuf, and, running to the southeast, reaches the Atchafalaya at Churchville, where it has a dam to retain its water for navigation, which would otherwise be like that of the De Glaise. A small steamer brings out freight, and it is transferred across the levee at Churchville to larger steamer in the Atchafalaya. The Bœuf runs in great sweeping bends, such as must have been made by some much larger stream than it now is. It passes between the Bay Hills and the bluffs of Rapides and Saint Landry parishes, which it touches only near the town of Washington for a few miles, but the drainage of which now furnishes the entire supply of water for its navigation, as the former connection with Red River has been cut off by dams on Bayou Robert and Bayou Rapides. The Red River deposit is found throughout the whole series of Bayous Teche, Bœuf, Vermillion, and Atchafalaya; beneath it is this blue clay, wherever banks are so washed as to disclose their ancient courses.

The Bœuf is now like a canal in its cross-section, and needs but locks to make it one in fact. Above Washington the width of gates need not exceed 25 feet and the length of locks 200 feet, which is sufficient for its commerce and that of the De Glaise, but below Washington the width should be 45 feet and the length 300 feet as well as on the Teche.

The reports on the Bœuf, Courtableau, and Teche, contain the results of their examinations, but there is need of a thorough survey of the Atchafalaya and its many connecting branches, known under many names, including Grand Lake and the whole series of channels from Red River down to Atchafalaya Bay. Small portions of these have been at times surveyed, but there is no connected accurate chart of the whole possible from existing data.

The connection of the whole series with the Mississippi will probably be by means of a lock in Bayou Plaquemine, and by this route will the commerce of the Red River and its tributaries, as well as the western delta bayous, reach New Orleans, which is the natural center of the whole delta country.

Major Benyaurd has made a survey, plans, and estimates for the improvement of this route in connection with the Red River; for this bayou navigation it is fully as important as for Red River.

Nowhere else in the United States are the conditions similar to those of this Mississippi region. In other places ridges form the divides between streams and water runs to the streams.

The area of tillable land includes in most cases all the land between where it is not mountainous, except those bottom-lands on the immediate banks of streams subject to so great an overflow as to endanger cultivation, while here in the delta all the tillable land is on the immediate banks of present or extinct streams, and the slope is back

towards swamps which receive the drainage and the overflow of the bayous, and which are covered with cypress forests on the older swamps, or with sea-marsh below near the Gulf. These banks are the only ridges.

From the dependence of these bayous on the Mississippi, or Red River, for their supply of water above the level above which tide-water rises, many of them have so little water that they are useless for purposes of navigation during all the low-water season, during which, in the sugar and rice districts, including all below Red River, the greatest depth is required for transportation of the products.

Railroads cannot supply the want of transportation in this region, as wagon-freighting is difficult from softness of the roads. Sugar-houses and other buildings are, when possible, built on the banks of bayous in order the more easily to roll freight to and from boats.

The plan recommended of making slackwater navigation for all these bayous, by making such locks as are needed to accomplish this object, and so making the locks that during high-water the gates can be opened, and needles of the dams removed, so that the current shall have free passage and sweep out the sediment deposited at low-water seasons, will cost—

For Bayou De Glaise, about	$50,000
For Bœuf and Courtableau, about	110,000
For Teche, about	60,000
For Charenton Canal, about	70,000
Total	290,000

The benefits to be derived from making the improvements recommended in this report cannot be even approximately estimated. The plantations along all the bayous would have good water communication throughout the year.

The bayous to which it is proposed to apply this system of slackwater navigation are, in fact, but natural canal channels, wanting but the locks to make them useful. Here, of all the streams on this continent, is the place to apply this system of improvements on a large scale, where the good to be derived from it will be greatest while its first cost is lowest.

Yours, respectfully,

H. C. COLLINS,
Assistant Engineer.

Maj. C. W. HOWELL,
Corps of Engineers, U. S. A.

APPENDIX N.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATE OF TEXAS.

REPORT OF MAJOR S. M. MANSFIELD, CORPS OF ENGINEERS, BVT. LIEUT. COL. U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 17, 1880.

GENERAL: I have the honor to forward herewith my annual reports relating to the works of river and harbor improvements under my charge for the year ending June 30, 1880.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Brevet Lieutenant-Colonel, U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF SABINE RIVER, TEXAS.

Report and estimates (survey of mouth of river) for improvement were made April 28, 1871.

Report of survey of "the bar at the mouth of Sabine River, in Sabine Lake, and to extend up the main channel of said river to Belzoria, Tex.," together with estimates for improvement, was rendered in 1873.

The appropriation of 1878, $10,000, to be applied to dredging a channel 5 feet deep across the bar at the mouth of the river to a depth of 5 feet in Sabine Lake at mean low-tide, with a minimum width of 100 feet or more, or so much thereof as the appropriation will permit.

The appropriation of 1879, $6,000, "for improving narrows of Sabine River above Orange, Tex., and to deepen the channel at the mouth of the Sabine River," is to be applied to improving "The Narrows."

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1880.

Dredging (under the contract of June 10, 1879, with Mr. Seth N. Kimball) began August 15.

It having been found impossible to load scows by reason of shoal water, one cut was made through the bar and the material thrown on the north

bank. This cut (about 4,000 feet in length) was completed in October, and a depth of 5 feet mean low-water obtained for almost the entire length of the cut. The widening and deepening of the channel across the bar was continued during October, November, December, 1879, and January, 1880, all material excavated being removed in scows to suitable dumping grounds. From August 15, 1879, to January 31, 1880, the amount of material dredged amounted to 40,320.2 cubic yards.

February 1, 1880, the contractor was permitted to remove his dredge-boat to the Neches Bar, with the understanding that the dredge-boat should return to the Sabine Bar and work out the balance of the appropriation. In June the contractor returned, and, by dredging and removing lumps left in the channel, completed the terms of his contract on June 22, having removed 2,247.2 cubic yards. This additional dredging left a completed channel the entire length across the bar 6 feet and deeper at mean low-tide, and from 70 to 100 feet in width.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1881.

March 20, 1880, a report was submitted with tracings of map covering the resurvey of "The Narrows," made under the provision of section 2 of the act of Congress approved March 3, 1879, making appropriations for the construction, repair, preservation, and completion of certain works of rivers and harbors and for other purposes, and it was then determined, with the appropriation of $6,000 made in same act, to improve that portion of the river above Orange known as "The Narrows," by—

1. Making a *cut-off* from the main river into "The Narrows";
2. Constructing a *dam* across "Old River" to increase the volume of water flowing through "The Narrows"; and
3. Removing all sunken logs and snags from the upper 5 miles of "The Narrows."

An advertisement bearing date May 25, 1880, invited proposals for the improvement above mentioned.

The following is an abstract of bids received in response to the advertisement:

Number.	Bidders' names and residences.	For cut-off, 315′ × 30′ × 4′ (completed).	For dam, 150′ (complete).	For removing logs, snags, at—	Aggregate.
				Per mile.	
1	William Mulvey, Orange P. O., Orange County, Texas ..	$1,650	$3,400	$500	$5,550
2	F. A. Hyatt, Orange, Orange County, Texas	2,100	3,705	400	6,205

The proposal made by William Mulvey was informal, no sureties, and otherwise defective in all essential particulars; and that of F. A. Hyatt, though formal, was, in the aggregate, beyond the limit of available funds.

Both bids were recommended to be rejected; and for the expenditure of the money to advantage, it was recommended, June 28, to readvertise for bids covering the work contemplated by the *cut-off* and the *removal of logs* and *snags;* deferring for a while the construction of the dam.

Appropriated by act of June 14, 1880, $5,000.

Recently, attention has been called to the fact that the dredged channel through the bar at the mouth of the river requires to be staked out;

complaint being made that the channel is difficult to navigate, owing to the accumulation of dredged material upon the north bank.

If requisite authority (just asked for) be given, a number of cypress piles, 400 to 500 feet apart, will be driven with the direction of the bank and marking the channel, so as to satisfy all demands of commerce there, at a cost of $250.

It is expected that after completing the work of making cut-off and removing obstructions to navigation, as well as marking out the dredged channel at the mouth of the river, there will remain a balance which may be sufficient to construct the dam across Old River, if considered necessary, or which may be applied to dredging channel across bar at the mouth of the Sabine River, as may be better determined hereafter.

ORIGINAL ESTIMATES.

Work at mouth (Report 1871)	$38,000
Removing snags, &c. (Report 1873)	18,000
Total	56,000
Appropriated (1878 to 1880)	21,000
Unappropriated balance	35,000

This balance can be profitably expended in continuing improvements in accordance with plans heretofore recommended; the work, especially the cut through the bar, is not considered permanent; estimates for maintaining the navigability of the river are merely based upon conjecture, and are liable to modification from year to year.

Full report of resurvey recently made in accordance with act of Congress approved March 3, 1879, "Resurvey of Sabine River from its mouth to East Hamilton," accompanies this report.

The work is located in the collection district of Galveston. The nearest light-house is at Sabine Pass.

Money statement.

July 1, 1879, amount available	$15,546 81	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$20,546 81
July 1, 1880, amount expended during fiscal year	8,701 57	
July 1, 1880, outstanding liabilities	827 37	
		9,528 94
July 1, 1880, amount available		11,017 87
Amount (estimated) required for completion of existing project		21,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		21,000 00

RESURVEY OF SABINE RIVER, TEXAS, FROM ITS MOUTH TO EAST HAMILTON.

REPORT OF MR. J. S. POLHEMUS, ASSISTANT ENGINEER.

BOLIVAR POINT, TEX., *May* 20, 1880.

CAPTAIN: I have the honor to submit the following report of the survey and examination of the Sabine River, from East Hamilton to its mouth, made under your direction from September 29 to December 8, 1879.

* * * * * * *

THE SURVEY.

Owing to the small appropriation ($1,800) for nearly 260 miles of river, the survey could be little more than a careful reconnaissance.

A compass line was run with a Gurley transit and the distances measured with a stadia, the adjustment of the hairs being frequently tested on a base measured with a steel tape.

The line was plotted in the field on the right-hand page of the note-book, and the topography on either side sketched in. Soundings were taken at least every 500 feet, and at every mile or two a cross-section was sounded.

The survey terminated in the cut just dredged across the bar at the mouth of the river, in Sabine Lake.

The length of line measured was 256 miles, and the sights averaged about five to the mile. In that part of the river called "The Narrows," extra care was taken.

The field work closed December 6, and the party arrived in Galveston December 8, being away seventy days, of which nineteen days were consumed in traveling.

The stage of the river was particularly favorable for a survey made with a view to improving the navigation, being the lowest known in several years; so that all obstructions, such as sand-bars, rocky and gravelly shoals, snags, fallen trees, sunken logs, &c., were visible and could be noted.

At no time during the survey was the water more than 1½ feet above extreme low.

A map of the river from East Hamilton to Sabine Lake has been made on eleven heets, on a scale of $\frac{1}{5000}$.

It was not commenced until February 2, 1880, as immediately after finishing the field work of the Sabine I received orders to make a similar survey of the Neches River.

GENERAL CHARACTER OF THE RIVER.

From East Hamilton the Sabine River flows in a general southerly direction for 247 miles, forming the boundary between the States of Louisiana and Texas. Its course, for the most part, is very tortuous and lies through rich bottom lands, from 2 to 5 miles in width, which are subject to overflow in high-water, and are covered with a luxuriant growth of hard-wood timber, such as oak, ash, hickory, black and sweet gum, &c.

These bottom lands are not cultivated and are bounded on each side by the high rolling land covered with pine forests. The lowest places usually have a growth of cypress or tubular gum.

The Sabine River from East Hamilton down has no large streams as tributaries, and the water-shed is very narrow; hence the periods of high-water depend almost entirely on the rains of upper prairie countries and are very irregular in their times and duration.

At East Hamilton the banks are about 23 feet high above the low-water, and the extreme range of water is 25 feet.

The water-way at this place at low-water is 120 feet wide, and averages only about, 100 feet for the next 50 miles below. It widens to 150 feet at Belgrade.

The upper 135 miles of river by this survey, or to what is called the "Raft," may be considered as a series of pools at low-water, held up by rocky ledges of sandstone, and gravelly shoals of ferruginous conglomerate or sand bars.

In several places the rocky strata cross the river, forming shoals and rapids that render navigation impossible at low-water. The most noted of these rocky shoals occur just below Sabinetown, and at Goodwin's Ferry, where a fall of 1¼ feet was observed in a distance of 100 feet.

The river is very tortuous in its course, and at low-water varies constantly in its depth from 10 feet and over to only a few inches.

The concave banks are clay and usually steep and caving. When the water is high, or at half banks, it undermines the trees growing at the edge, which fall and often lie across the entire water-way and rest on the opposite shore.

The sand bars are quite numerous, and lie diagonally across the river

Occasionally the river in its course touches the bluffs or high land, some of which are not less than 100 feet high.

A few farms appear on the upper part of the river, and cotton and corn are cultivated.

Just above Stark's Ferry, 135 miles from East Hamilton, the "Raft" begins. It is that portion of the river, some 11 miles in extent, formed about fifteen years ago by the opening up of a bayou or slough, and its gradual enlargement as the original channel (or Old River) became choked with drift. This section of river, known as the "Raft," is about 150 feet in width; it presents many difficulties to navigation and causes much annoyance to lumbermen while floating down logs.

The current is swift and the channel crooked and shallow at low-water, as shown on the sketch. It contains a great many hard-wood snags and fallen trees, but since the Old River has become entirely closed it is washing out and improving.

Belgrade, at the lower end of the "Raft," is 90 miles from Orange; one family lives here and keeps a small store.

From Belgrade the river considerably improves until the Narrows are reached. It will average 200 feet in width and is less obstructed by snags than the river above.

Throughout all this part of the river very little good arable land exists in the immediate vicinity of its banks.

The chief industry is the timber business, and large and valuable rafts of pine and cypress logs are floated down to the mills at Orange.

Reliable information as to flood-levels and periods was difficult to obtain, as they vary so much every year. The winter-rise, however, usually begins in December, and lasts about three or four months. The extreme range between high-water and low-water is about 25 feet at East Hamilton and only 10 feet at the head of the Narrows.

When the water is high it floods the bottom lands and flows across many of the bends, forming cut-offs, and all the rocky and gravelly shoals and sand bars are covered

THE NARROWS.

This part of the river merits a more careful description, as it is at present the most seriously obstructed for a long distance above Orange, and is rapidly deteriorating, and could be greatly improved by the expenditure of a small amount of money.

The head of the Narrows is 30 miles above Orange and the foot 12 miles; they are consequently 18 miles in length. They were formed, before the official boundary survey of Maj. J. D. Graham, by the opening of a chain of sloughs and the formation of a raft in the Old River a few miles above Niblett's Bluff.

At present more water flows down Old River than the Narrows. The main stream divides at the head of the Narrows, as shown on the map, and by far the larger quantity goes off to Old River; for a mile this water flows through a channel which was not the original river, but only a small bayou twenty years ago; it is enlarging, however, and is now some 20 feet deep and over 100 feet wide.

It is a great source of annoyance to timbermen, as their logs and rafts float down this way, instead of through the Narrows, and mingle with the raft in Old River and are lost.

The water which flows down Old River runs under and penetrates through the raft for about half a mile, when the main channel divides into several small bayous or sloughs, which flow through a cypress and tubular gum swamp for about 2 miles, and which finally come together again and form a deep, wide river some 2 miles above Niblett's Bluff.

When the closing of Old River took place it is impossible to say. It must have been many years ago, as it is beyond the recollection of the oldest inhabitant, and the small sloughs into which the river is divided flow through a cypress swamp in which the trees are 3 and 4 feet in diameter.

Some 3¼ miles from the head of the Narrows, Swayne's Bayou enters; it is simply a slough through which some of the water, backed up in Old River by the raft, flows back into the Narrows.

The first 5 miles of the Narrows from the head is the only part that needs improving; here the water-way averages only 100 feet in width, and at lowest water has a depth of not more than 2 feet in places. The bottom is generally sandy and covered with sunken logs.

In "driving" timber through the Narrows jams often occur and many logs sink, get covered with sand, and form permanent shoals and sand bars, which lessen the water-way and tend to throw more water down Old River.

There are two bad bends across which the water makes when it is high, forming troublesome eddies for the lumbermen.

From 1¾ miles below Swayne's Bayou, or 5 miles from the head of the Narrows, there is, at least, at all times 5 feet of water. There are no overhanging trees or snags, and the river from this point to its mouth needs no work upon it.

The tides of the Gulf affect the level of the river as far up as Morgan's Bluff, 20 miles from Orange, but depend chiefly on the force and direction of the wind.

Mr. Leavenworth, who made a survey of the Sabine River, under the direction of Maj. C. W. Howell in 1872, states that the water-way of the Narrows is exceedingly tortuous and crooked, though deep and comparatively clear of obstructions, and from all I could learn from old lumbermen the river is in a much worse condition now than it was a few years since.

The river below the junction of Old River and the Narrows widens out to a fine stream 300 feet in width. At Orange it is 500 feet wide.

One mile below the Narrows the Louisiana Western Railway crosses on a new iron draw-bridge. The banks here are low, and are generally covered with cypress and tubular gum trees draped with grey moss.

Below Orange the river widens out to over 1,000 feet.

The "cut-off," 2 miles below the town, has deepened until now there is not less than 12 feet of water in it. From here down trees gradually cease, and their place is taken by coarse grass and sea-cane.

Shortly before Sabine Lake is reached the river divides into two passes, the east and middle passes; and the middle pass has a small but deep fork, called west pass, and it was along this the survey line ran, as at its mouth the new cut into the lake was being dredged. It extends to 5 feet of water.

Sabine Lake is shoal, with a soft, muddy bottom. The banks here are subject to constant overflow, and the only habitable spots are the shell mounds, which are sometimes 400 yards long and 40 feet high.

GENERAL DESCRIPTION OF THE TOWNS AND COUNTRY.

East Hamilton, the initial point of this survey, is situated in Shelby County, Texas. It contains two stores and about thirty inhabitants. It would, however, be quite a shipping point for cotton provided navigation could be relied on all the year, as the neighboring country is good farming land and considerable cotton raised, most of which is hauled to Shreveport, La. Mr. James Payne states that last year 1,800 bales of cotton were shipped by river from this place to Orange.

Pendleton, in Sabine County, has only one store and a cotton warehouse. Two families live here, and 1,000 bales of cotton were shipped last year.

Sabinetown is a small settlement of a half dozen families and one store.

There are no more towns on this river until we reach Orange. Some little cotton is shipped from a few landings. About every 15 miles a single family can be found living on the river and tending a ferry. The reason of such a scarcity of population on the river is partly due to the fact that the bottoms are subject to overflows and cannot be cultivated, and partly to the prevalence of malarial fevers near the river in the summer months. Ten or 12 miles back the country is better settled and some cotton grown. Valuable forests of pine grow on either side of the bottoms, and cypress brakes are frequent near the river. This year 45,000 logs were cut in the vicinity of the river, and at the time of the survey were waiting for the first rise to be floated down to the mills at Orange.

Orange has grown very rapidly in the last few years. The Texas and New Orleans Railway has only been running there within a year, and the Louisiana Western Railway will be completed this spring, connecting it with New Orleans. The lumber business is the principal industry of the place, and there are several large saw and shingle mills in operation. There were three steamboats ready to run on the Sabine this year, the Wren, the Era, and the Lark.

IMPROVEMENTS.

The Sabine River may be relied on for about three months in each year for navigation, with boats drawing 3 feet, from Orange to East Hamilton.

If the river could be improved so as to have navigation throughout the year, most, if not all, of the cotton grown in the counties and parishes adjoining the river would find its way to market by boat. The volume of the river is so small, however, during the summer and autumn, that only an expensive system of dams and locks would be effective, which the sparsely settled state of the country and the navigable value of the stream would not seem to justify. As it is, when the water is up steamboats make the trip to East Hamilton and back, from Orange, in about twelve days, and no improvement is necessary except at low-water to cut out all snags and overhanging or fallen trees.

In 1856 the legislature of Texas appropriated $51,455 for the improvement of the Sabine, and in 1874 a considerable amount of State land, for the same purpose; the snags were cut out, and some of the timber along the banks deadened, but no useful results of this expenditure remain.

Dismissing, then, any plan to secure low-water navigation between Orange and East Hamilton, and turning our attention to the Narrows it is seen that if they could be improved boats of light draught could go as far as Belgrade most all the year. This is 90 miles from Orange by water, and it is below this point that the greater part of all the logs are put into the river.

It would be desirable to cut out some fallen trees and snags between the head of the Narrows and Belgrade.

The lumber business is by far the most important interest on the river.

Last summer the small steamboat Lark, drawing a little less than 2 feet, was twenty-two days getting through the Narrows.

IMPROVEMENT OF THE NARROWS.

With the money and time allowed I could not make a thorough examination and survey of Old River, with a view of removing the raft and opening it up and allowing the Narrows to close, but from the careful reconnaissance made it would undoubtedly be more economical to use the present channel of the Narrows.

To do this, two things must be done. 1st. Some obstruction should be thrown across Old River to divert the water from it into the channel of the Narrows. 2d. The sunken logs and snags should be removed from the first 5 miles of the Narrows.

It would also be advisable to assist nature and make three cut-offs, now nearly formed, one especially, which, of itself, would tend to throw more water down the Narrows. It is only 320 feet across now, and the bank would not average over 8 feet above low-water. The trees have already been cut off and the water runs over in a high stage. It is marked A B on the chart. The other two proposed cut-offs marked C D and E F on the chart are not over 100 feet across and would straighten and shorten the river very much, and save the necessity of working on quite a stretch and the raising of many logs.

It is impossible to state how many saw-logs are sunk in the Narrows as they are for the most part under water and covered with sand. Those that were exposed at the time of the survey are indicated on the chart. It is also difficult to form an estimate of the cost of hauling them out on the banks. It is safe to say, however, that the removal of 500 sunken logs and 100 snags from the sand would greatly improve the navigation.

To improve the Narrows, then, we would recommend to make the cut-off marked A B from the main river into the Narrows 320 feet long, 40 feet wide, and 5 feet deep at low-water. To throw some obstruction across the Old River at G H on chart, which need not be water-tight, a double row of piles with brush and trees between would do. To haul out with some kind of snag-boat the most troublesome sunken saw-logs and snags; and lastly to make the other two cut-offs indicated on the chart. It might be necessary to block up Swayne's Bayou, which could easily be done, as it is narrow.

If these alterations were made it is thought that the volume of water flowing in the Narrows would be more than doubled, its velocity would be increased, and it would deepen the channel.

APPROXIMATE ESTIMATE.

Making cut-off at A B:	
The removal of 5,000 cubic yards of clay, at 50 cents	$2,500
For making pile and brush obstruction 150 feet long, at G H, across Old River	2,000
For making two other cut-offs, each about 100 feet long, at about $500 apiece.	1,000
For hauling out and removing sunken logs and snags from the bed of the Narrows	5,000
For superintendence and inspection, about	2,000
For cutting out snags from the Narrows to Belgrade	5,000
Total	17,500

Whatever work is contemplated will have to be done late in the summer or autumn when the water is at its lowest, some time in August, September, or October. The country then is very sickly from chills and fever and malarial fevers, but the logs cannot be gotten at nor any of the work prosecuted to advantage when the water is not low. The banks are low except at Morgan's Bluff, and the extreme high-water about 10 feet above the low.

The chart of the Narrows was made by plotting the stations with a large protractor and is drawn on a scale of $\frac{1}{5000}$.

Very respectfully, your obedient servant,

J. S. POLHEMUS,
Assistant Engineer.

Capt. C. E. L. B. DAVIS.
Corps of Engineers, U. S. A.

SURVEY OF THE NARROWS OF SABINE RIVER, ABOVE ORANGE, TEXAS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., March 20, 1880.

GENERAL: I have the honor to submit herewith a report on the survey of the Narrows of the Sabine River, above Orange, Texas, being a portion of the river which has been surveyed under the provision of section 2, of the act of Congress approved March 3, 1879, "making appropriation for the construction, repair, preservation, and completion of certain works of rivers and harbors, and for other purposes."

The first section of the act makes an appropriation of $6,000 for improving Narrows of Sabine River above Orange, Texas, and to deepen the channel at the mouth of the Sabine River.

Major Howell's suggestion to defer the preparation of a project for the expenditure of this appropriation until the completion of the resurvey of Sabine River was approved by the Chief of Engineers May

31, 1879. This duty is now imposed upon me. So much of the survey as is embraced in the provision of the appropriation act has been completed, and I am now enabled to submit a report with recommendation and estimates.

Major Howell says that after survey it can be decided whether it may be best to expend the money at the Narrows or on the bar at the mouth of the river.

Under an appropriation of $10,000, made in act of 1878, the bar at the mouth of the river is now being dredged to give a channel of 5 to 6 feet of water, so we may dismiss for the present the consideration of any further expenditure at this point and devote the whole of the $6,000 to improving the Narrows above Orange.

The survey was made by Assistant Polhemus, and his report is very full, showing distinctly the character and location of the obstructions to navigation and indicating what is necessary in the way of improvement.

To improve the Narrows, then, it will be advisable, first, to throw some obstruction across Old River to direct the water into the channel of the Narrows; second, to remove sunken logs and snags from the first 5 miles of the Narrows.

It would also be advisable to assist nature and make three cut-offs, now nearly formed, especially one near the head of the Narrows where the trees have already been cut off and the water runs over in a high stage.

It is impossible to say how many saw-logs and snags will have to be removed, as they are mostly under water and covered with sand. Exposed ones are indicated in the chart. It is safe to say, however, that the removal of 600 logs and snags would greatly improve the navigation. It might be necessary to dam Swayne's Bayou, which could easily be done.

It is thought that if these changes were made, the volume of water flowing through the Narrows would be more than doubled, the velocity would be increased and the channel deepened.

APPROXIMATE ESTIMATE.

Making cut-off at A B on accompanying sketch, involving the removal of 5,000 yards of clay at 50 cents	$2,500
Obstructing Old River at G H	2,000
Making two other cut-offs	1,000
Removing logs and snags from the bed of the Narrows	5,000
Superintendence and inspection	1,000

This work will have to be executed late in the summer when the water is at its lowest stage.

For the expenditure of the $6,000 available, I have to recommend—

1st. Cut-off at head of Narrows, $2,500.

2d. Dam in Old River, $2,000.

3d. Removal of logs and snags from bed of river to the extent the funds will permit.

I recommend that the work be done by contract.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Brevet Lieutenant-Colonel, U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

N 2.

IMPROVEMENT OF NECHES RIVER, TEXAS.

Report, with estimates and plans (survey of 1872-'73), was submitted December 30, 1873.

First appropriation of $8,000 was made in 1878, "to excavate a channel 5 feet deep at mean low tide, and 40 wide, or so much thereof as the amount will permit, through the bar at the mouth of the river."

Second appropriation, $5,000, given in 1879, for application "to further improving the channel through the bar at the mouth of the river."

Under the first appropriation contract was entered into June 10, 1879, for excavating and removing material, at 22½ cents per cubic yard; under the second appropriation (contract of November 14, 1879) the price of dredging, &c., was put at 32¼ cents per cubic yard; Mr. Seth N. Kimball, of Mobile, Ala., being the contractor under both appropriations.

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1880.

The contractor's dredge-boat was transferred from the bar at the mouth of the Sabine River to the bar at the mouth of the Neches River on the 31st January, 1880, and commenced work on the Neches Bar (under provision of first contract, June 10, 1879) the 2d of February, beginning at the outer or lake end of the bar, the material excavated being dumped on the west bank.

To procure the 5-foot dredged channel across the bar from the 5-foot depth of water in the river to the same depth in Sabine Lake, the first cut was made a total length of 10,300 feet; necessitating the removal of 29,014.1 cubic yards of material, and absorbing the funds of the appropriation available for this contract, which was completed April 30, 1880.

Work under the second contract (November 14, 1879) began May 1, 1880; the commencement being made on the second cut (widening first cut), and continued toward the upper and until the cut was completed on the 29th, on which date the dredge was removed to a more outward point, and work proceeded toward the end of the second cut at the angle in the channel. All material excavated under this contract was towed away in scows and dumped on suitable dumping grounds. Contract was completed June 18, 1880.

With the appropriations of 1878-'79 ($13,000), there has been completed a channel across the bar of the required depth, viz, 5 feet (and more) at mean low tide, averaging 60 feet in width (excepting a gap of about 1,200 feet, on the shoalest portion of the bar, over which there is a channel of about 30 feet, or one cut, wide) for the entire length of the channel from the 5-foot depth of water in Sabine Lake to the 5-foot depth in river above.

The work under both contracts was satisfactorily done.

PROPOSED OPERATIONS OF THE YEAR 1880-'81.

To expend the amount appropriated by act of Congress, approved June 14, 1880, viz, $5,000, in continuing improvement of channel across the bar at the mouth of the river, by dredging, deepening, and widening the cut recently made under contract with Mr. Seth N. Kimball; estimated amount of material to be excavated and removed (30 cents per

yard) 13,500 cubic yards; and to be done by contract, after inviting proposals.

Original estimate (1874)	$26,318 05
Amount appropriated (1878–'80)	18,000 00
Unappropriated balance	8,318 05

Which amount can be profitably expended in the fiscal year ending June 30, 1882, in continuing dredging to improve the channel for navigation across the bar at the mouth of the river.

The work is located in the collection district of Galveston. The nearest light-house is at Sabine Pass.

A resurvey of the Neches River, Texas, from its mouth to Bevilport, was made during period between dates December 19, 1879, and January 31, 1880, the results of which are incorporated in a special report herewith submitted.

Money statement.

July 1, 1879, amount available	$12,662 08	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$17,662 08
July 1, 1880, amount expended during fiscal year	11,246 23	
July 1, 1880, outstanding liabilities	1,308 55	
		12,554 78
July 1, 1880, amount available		5,107 30
Amount (estimated) required for completion of existing project		8,318 05
Amount that can be profitably expended in fiscal year ending June 30, 1882.		8,318 05

RESURVEY OF NECHES RIVER, TEXAS, FROM THE MOUTH OF THE NECHES TO BEVILPORT.

REPORT OF MR. J. S. POLHEMUS, ASSISTANT ENGINEER.

BOLIVAR POINT, TEX., *July* 1, 1880.

COLONEL: I have the honor to submit the following report on the survey of the Neches River, Texas, from Bevilport to its mouth, made in January, 1880.

On my return from the survey of the Sabine River, I received orders from Captain Davis to make a similar survey of the Neches River, and in pursuance of his instructions left Galveston December 19, 1879, with a party of three men and survey equipment, and proceeded by rail to Beaumont, Tex., at which place I hired an ox-team, and transported my party, together with the three skiffs I used on the Sabine River, to Bevilport, on the Angelina River, 7 miles from its junction with the Neches, where I arrived December 25, 1880. December 27, a cross-section of the river and banks was made at Bevilport, and the survey commenced.

SURVEY.

The survey was in all respects like that made of the Sabine River. The appropriation being only $800, nothing but a careful reconnaissance was attempted.

A compass line was run along the river's banks, and all distances were measured with a stadia. All obstructions to navigation, such as shoals, snags, sunken logs, &c., were sketched in their proper place, and soundings were taken about every 500 feet.

Length of line measured from Bevilport to Sabine Lake was 157 miles.

Thirty-five cross-sections were taken, and whenever the height of flood-level could be ascertained it was measured and noted.

The survey of the river between Bevilport and Yellow Bluff, 63 miles, was made at a very low stage of the river, and all snags and obstructions to navigation, as well as the general character of the river at its lowest water, was observed.

While we were at Yellow Bluff a rise of 9 feet 2 inches took place in a single night, and from that place to Weiss Bluff the water was from 9 to 6 feet above extreme low,

and the obstructions were all covered and could not be seen. The very bad portions of the river, however, are all above Yellow Bluff.

Most of the information as to the character of the river at low-water between Yellow Bluff and Weiss Bluff was obtained by inquiries from old settlers, and from men engaged in floating logs to Beaumont.

The survey was completed to the mouth of the river January 26, and the party returned to Galveston and was disbanded January 30, 1880.

The work has been plotted on a scale of $\frac{1}{10000}$ on three sheets.

The plotting commenced May 24, and the maps were completed July 10, 1880.

GENERAL DESCRIPTION OF RIVER.

From its junction with the Angelina River the Neches flows in a southerly direction to Beaumont, 130 miles, from which place it flows southeast for 27 miles, to where it empties into Sabine Lake, only 4 miles from the mouth of the Sabine. The river flows through bottom-lands from 2 to 5 miles in width, beyond which are rolling pine-lands. The bottom-lands are very fertile, the greater portion of them subject to overflow each year, and very unhealthy. They are not cultivated to any extent, and are covered with a heavy growth of oak, gum, hickory, &c.

The general height of the bottom-lands at Bevilport above the low-water of the river is about 20 or 30 feet, and they decrease proportionally as we near the coast.

The course of the river is extremely tortuous in its valley, and, as it curves along, the banks on the convex side are abrupt and caving, and slope down again as we go back from the river. The concave sides of the bends are low, and slope gently. As the caving banks wear away at each rise in the river, trees are undermined and fall into the stream, filling it with snags and obstructions.

When the river is low in summer and early autumn the volume of flow is very small.

The annual rise usually begins in December and lasts until April. The river rises 15 or 20 feet, and, if it were not for the fallen trees and snags, navigation would be very good as far as Bevilport.

The range between high and low water is:

	Feet.
At Bevilport	26
At Town Bluff	28
At Weight's Landing	22
At Yellow Bluff	21
At Beaumont	11

In giving a more particular description of the river it seems natural to divide it into three sections.

FROM BEVILPORT TO YELLOW BLUFF.

This includes 7 miles of the Angelina River, which at low-water is about 125 feet wide and varies in depth from 8 inches to 10 feet. The bed of the river contains many snags and sand-bars. At the junction the Neches and Angelina unite, and the volume of water is nearly doubled. Between the junction and Yellow Bluff the Neches has no large streams as tributaries, and the water-way will average 150 feet in width, and varies in depth from 1 foot to 15 feet.

At low river very little water is running in the channel, and there are numerous shoals of sand and gravel. There are a great many snags and fallen trees in the bed of the river, and navigation is practically impossible without a rise of several feet. No rocky shoals were found on the river. The most troublesome portion is near Pebble Island, 4 miles above Yellow Bluff.

FROM YELLOW BLUFF TO WEISS BLUFF.

The river is about 150 feet in width, and, if the information obtained from all the lumbermen is correct, has a depth at low-water of not less than 2¼ feet at any place.

William Long & Co. (lumbermen and mill-owners) have had their men cut out all the snags down to the level of low-water, and the river is in a very good condition when the water is not extremely low.

FROM WEISS BLUFF TO SABINE LAKE.

The river can be navigated at all times of the year by light-draught steamboats.

Between Weiss Bluff and Beaumont the river is deep, and a steamboat runs regularly. Entering this portion, it has two large-sized creeks as tributaries, Village Creek and Pine Island Bayou. From Beaumont to the lake the Neches is wide and

deep and the banks low and swampy. It is about 1,000 feet wide near its mouth. It empties into Sabine Lake over a mud-bar, on which at the time of the survey there was not more than 3 feet of water, but which has since had a channel dredged through it 6 feet in depth, and any of the small vessels which can cross Sabine Lake can get into the river.

PRINCIPAL TOWNS AND LANDINGS.

Bevilport, the initial point of the survey, is a very small town containing two small variety stores and a cotton warehouse, and might number twenty inhabitants. It is quite a shipping-port for cotton, which is the staple product of the neighboring country.

The next place is *Town Bluff*, a small town, situated on a high bluff on the right bank of the river half a mile back. It has three stores and ships 700 bales of cotton.

Farther down the river are two landings from which cotton is shipped.

About 3,000 bales of cotton are shipped from all the landings along the Neches. most of which this year found its way to market by wagon, owing to the protracted low-water. Valuable forests of pine grow near the river and furnish the mills at Beaumont.

Below Yellow Bluff, in the immediate vicinity of the river, the land is but little cultivated. The banks are low and subject to overflow.

Beaumont is the largest town on the river, and numbers about 2,000 inhabitants. It contains seven saw and two shingle mills. The Texas and New Orleans Railroad crosses the river at this point. The lumber business is the chief industry of the place, and the town is growing and improving rapidly.

Below Orange there are no towns. There were two saw-mills before the Texas and New Orleans Railroad was built.

There were three steamboats running on the Neches last year, one of the boats only to Weiss Bluff. Long & Co. have built a tramway 3 miles back into the country from Yellow Bluff, and float down to the mills at Beaumont a great many logs. As near as could be ascertained, 35,000 logs were floated down this year. Mr. Goodhew cut and floated to Beaumont 45,000 pine railroad-ties; besides these there were about 15,000 cut by other parties.

IMPROVEMENTS.

During the summer, while the river is at low stage, there is so little water running and so many shoals and sand-bars over which there is less than 1 foot in depth, that it would seem impossible to secure navigation throughout the year except by means of an expensive system of dams and locks, which the present state of the adjacent country does not warrant.

At present navigation for boats drawing 3 feet of water can be relied on for about 3 months in each year as far up as Bevilport, commencing usually in December; but this navigation is rendered dangerous on account of the many snags and fallen trees which should be either cut down to the level of low-water or dragged out of the bed of the stream.

The river below Beaumont and above to Weiss Bluff needs no improvement.

Above Weiss Bluff to Yellow Bluff it is quite clear of snags; this leaves 63 miles from Yellow Bluff to Bevilport on which work should be done.

The principal snags and fallen trees are sketched on the map. There would be about 100 to the mile and about 20 overhanging trees to be cut away.

It is thought that the expenditure of about $250 per mile would remove all the important snags and large overhanging trees, or for the river between Bevilport and Yellow Bluff, $15,000.

Very respectfully, your obedient servant,

J. S. POLHEMUS,
Assistant Engineer.

Bvt. Lieut. Col. S. M. MANSFIELD,
Major of Engineers, U. S. A.

N 3.

IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, TEXAS.

Captain Davis, Corps of Engineers, assistant to my predecessor, Major Howell, has been in immediate charge of this work, and he submits herewith a report of operations for the year past till time of my assuming charge in February last, when I relieved Major Howell of the

charge of certain works in Texas, by virtue of Special Orders No. 6, Adjutant-General's Office, dated January 9, 1880.

Taking charge at a season of the year when active operations were impossible, I have devoted myself to a careful study of the history and progress of the work to the present time while developing a project for future operations.

A history of the work with the suggestions and recommendations of the engineers in charge and of the several Boards of Engineers that have had the matter under advisement are summarized in the reports of the last board, dated August 9, 1879, and June 7, 1880, published herewith.

The theory upon which the Board relies is that of contraction of the outlet to force the outflow into a narrow channel directed upon the bar to effect its removal and lessen, if not entirely prevent for a long time to come, its reformation.

Through all the literature of the subject, which is well-nigh exhausted, this principle upon which we depend for securing deep water over the bar remains unquestioned, and its application offers every guarantee of success.

The suggestions and recommendations of the Board as to details of construction are tentative only, the selection of a suitable construction being wisely left to the judgment of the officer in charge.

The magnitude of this work, and the absence of suitable materials with which to construct it, has heretofore been the great obstacle to its advancement, and its estimated cost has been placed at high figures.

The experiment of a gabionnade was made as offering a cheap and successful solution of the problem. So far as it was applied on the Fort Point side of the channel to the improvement of the inner bar it was successful, and we now have 20 feet of water over the inner bar; but its further application to the Bolivar jetty, with the object of effecting the depth over the outer bar, proved unsuccessful, and the system has been discarded.

It is now intended to build the jetties of brush and stone on a system that undoubtedly will succeed, for it has been applied to open-sea exposure at the mouth of the Maas, where it has realized all anticipations and established a certain and economical way of constructing these sea-works on sand-coasts.

The eminent Dutch engineer, Caland, says:

> On a movable bottom this method of construction offers guarantees of solidity which recommend its employment wherever the materials for fascines can be readily had.

There is no longer, as heretofore, a question of procuring suitable materials in sufficient quantity and at a reasonable cost.

Careful estimates have been prepared, based on actual practice here, and they show the cost of construction will fall much below the figures generally thought to be necessary. These estimates are made upon the supposition that the work will be continuous, and $500,000 is the sum that should be appropriated annually for this purpose. Its advantages are that very little plant will be required; one or two powerful, light-draught tug-boats and a dozen barges, with anchors and cables and ways for building mattresses, is all. Contractors can have suitable material delivered in the vicinity of the work, and skilled labor for making and handling the mattresses can readily be obtained.

Should the Government purchase the plant, which I estimate $40,000 will cover, contractors could make use of it; and the work will pay for this plant but once, and should contractors fail to give satisfaction, the plant being ready, the work could be prosecuted without interruption.

The bulk of the appropriations will go directly into the work.

I am confident the application of the system here will be attended with perfect success.

I invite attention to the accompanying report of Assistant Engineer H. C. Ripley, to whom I am greatly indebted for so clear and comprehensive an exposition of our plans and estimates for the improvement of this harbor.

STATISTICS OF THE PORT OF GALVESTON, YEAR ENDING DECEMBER 31, 1879.

Exports of domestic produce.

Cotton to foreign ports	$16,511,525	
Cotton to domestic ports	9,859,075	
		$26,370,600
Wool, 19,873 bags		1,530,220
Hides—bales, 9,993; bundles, 8,434; loose, 7,637		2,206,550
Cattle		402,000
Tallow		170,000
Preserved meats		12,800
Bones, 6,000 tons		78,000
Horns		57,300
Peltries		85,000
Pecans		19,400
Beeswax		17,200
Hair		4,000
Oats (wheat and corn, none)		16,700
Cotton-seed, 15,000 tons		120,000
Cotton-seed oil, 11,500 barrels		184,000
Cotton-seed oil-cake, 77,000 sacks, foreign		154,000
Sugar		206,580
Molasses		81,620
Total		31,715,970
To foreign ports		16,665,670
To domestic ports		15,050,300
Total		31,715,970

Value of imports for the years 1878 and 1879, each ending December 31.

Articles.	1878.	1879.
Groceries	$5,981,500	$7,813,700
Dry goods	2,280,000	2,795,000
Notions	430,000	661,090
Boots, shoes, and hats	1,533,420	1,785,650
Hardware	595,100	704,200
Clothing	604,000	735,000
Crockery	35,000	78,000
Drugs	200,000	200,000
Lumber, shingles, and laths	220,000	225,000
Wines and liquors	470,000	540,000
Furniture	230,000	270,000
Lime and cement	18,000	25,000
Bricks	38,000	48,000
Sash, doors, blinds, &c	120,000	147,000
Paints and oils	78,000	92,000
Iron-ties and baling stuffs	969,850	997,400
Coffee	519,000	683,000
Coal	80,000	88,500
Railroad iron and fastenings	112,000	340,000
Railroad rolling-stock	45,000	102,500
Total	14,558,930	18,331,040

Increase of 1879 over 1878, 26 per cent.

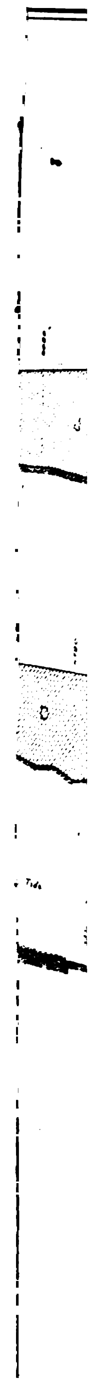
The above are the imports for the Galveston trade only, and are estimated as being only one-fourth of the imports at Galveston for the State at large, which would be for 1879, $73,324,000.

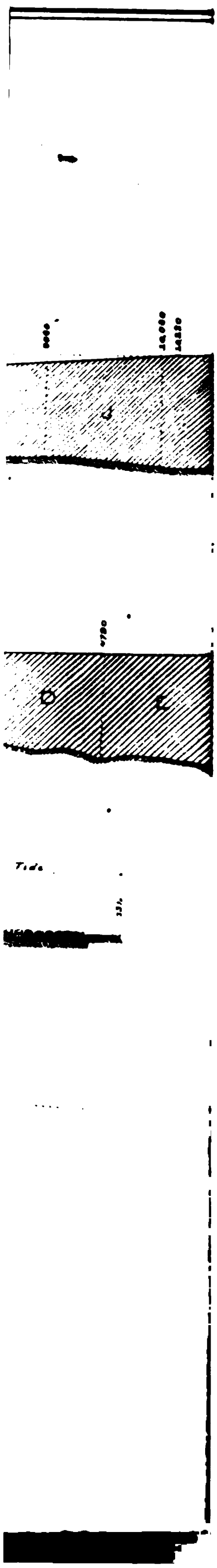
ENTRANCE

TO

Galveston Harbor

TEXAS





STATEMENT OF DUTIES COLLECTED AT THE CUSTOM-HOUSE, GALVESTON, ON IMPORTED GOODS FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1879, FURNISHED BY E. M. PEASE, ESQ., COLLECTOR.

January	$2,645 81
February	1,135 45
March	5,407 83
April	3,314 99
May	1,719 74
June	1,755 52
July	2,841 53
August	26,809 11
September	11,842 22
October	8,187 61
November	14,198 91
December	48,684 79
Total 1879	128,543 51

Total for calendar year ending December 31, 1878, $43,007.41; increase of 1879 over 1878, 200 per cent.

In addition to other foreign goods to be entered at this port during this year, there have been ordered from England 100,000 tons of iron and steel rails, which will give a revenue in duties of over $160,000.

The above statistics were furnished by kindness of Mr. James Sorley, of Galveston, Tex.

The work is located in the collection district of Galveston. The nearest light-house is on Bolivar Point, at entrance to Galveston Bay.

PAPERS ACCOMPANYING THIS REPORT.

A. Report of Capt. C. E. L. B. Davis, Corps of Engineers.
B. Report of Mr. H. C. Ripley, assistant engineer.
C. Plans and estimates.
D. Analysis of current meter.
E. Diagrams of wind.

Money statement.

July 1, 1879, amount available	$117,462 80	
Amount appropriated by act approved June 14, 1880	175,000 00	
		$292,462 80
July 1, 1880, amount expended during fiscal year	80,894 51	
July 1, 1880, outstanding liabilities	2,000 00	
		82,894 51
July 1, 1880, amount available		209,568 29
Amount that can be profitably expended in fiscal year ending June 30, 1882.		500,000 00

BUSINESS OF PORT OF GALVESTON FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

Total receipts from all sources, $346,298.97, of which $318,211.24 was from duties on imports.

Total value of imports from foreign ports, $1,094,731.

Total value of domestic products exported to foreign ports, $16,726,825; of which cotton amounted to $16,519,124, and all other articles $207,701.

Value of foreign products exported to foreign ports, $37,028.

Entrances and clearances of vessels at the port of Galveston for the year ending June 30, 1880.

Vessels.	Entries.		Clearances.	
	No.	Tons.	No.	Tons.
AMERICAN COAST.				
Atlantic ports	193	183,180	109	147,919
Gulf ports	113	103,621	246	146,604
FOREIGN PORTS.				
American	27	7,893	26	10,119
Foreign	168	110,079	147	88,805
Total	501	404,773	528	393,537

A.

REPORT OF CAPTAIN C. E. L. B. DAVIS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 3, 1880.

SIR: I have the honor to submit the following report of operations for improving the harbor at Galveston, Tex., from the commencement of the fiscal year 1879 to February 25, 1880, the date of your arrival at Galveston, Tex.

BOLIVAR GABIONNADE.

The construction of the gabionnade at Bolivar Point was continued up to November 28, 1879, when the manufacture and sinking of gabions were discontinued in accordance with verbal instructions received from Maj. C. W. Howell, Corps of Engineers, U. S. A.

The following table exhibits the monthly progress made during the time of sinking gabions:

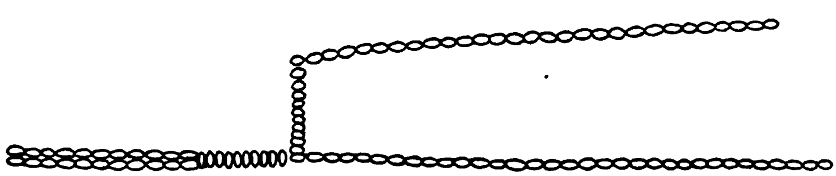
Date.	Number of gabions.	Total number.	Length.	Total length.
1879.				
July	104	709	1,262	8,590
August	63	772	593	9,183
September	38	In wings.	....	....
October	30	802	383	9,566
November	3	805	40	9,606
	238	....	2,278	....

The total length of line to 18 feet of water outside the bar is 16,500 feet; 9,606 feet of gabionnade having been constructed, there remained uncompleted on the cessation of work a length of 6,894 feet.

During the month of July 106 gabions were sunk in the Bolivar gabionnade. An examination of the position of the gabionnade put down in July was made in September.

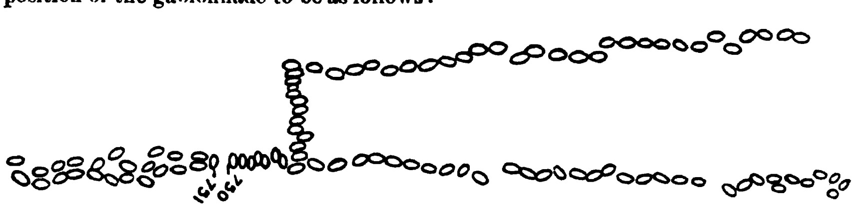
One gabion was missing, and one was found to the northward of and considerably out of line. This latter gabion was put down at the close of a day's work; was but partially filled with sand; and two days afterwards was found to have shifted to its position revealed by the September examination. It is probable that the missing gabion shifted in a similar manner, but so far out of line as not to be discovered by the surveying party.

In August and September 63 and 38 gabions, respectively, were put down, disposed in the following manner:



The gabions were placed very regularly and in line, as they were sunk in smooth and shallow water, and could readily be seen in position when first put down.

An examination of this portion of the gabionnade, made in November, showed the position of the gabionnade to be as follows:



The two gabions Nos. 750 and 751 were carried away, leaving the mats and concrete blocks in position. These two gabions were discovered missing a few days after being

put down. As they were filled properly, no cause can be assigned for their disappearance.

In the partial inclosure formed by the wing and return line, put down in September, it was thought a rapid accumulation of sand would take place, but no such effect occurred.

During the month of October 30 gabions were placed in the gabionnade. Of these 30 gabions 5 had entirely disappeared, when examined in December, and others showed considerable displacement.

In November 8 gabions were put down. Four of these were put down on the 3d, the outer two of which had disappeared on the 19th and were replaced, and two more sunk on that date. When the examination was made December 16, only 3 of the 8 gabions remained.

At the outer end where the gabions disappeared the mats remained as they were placed. At this point the construction of the Bolivar gabionnade was discontinued.

MATTRESS JETTY.

In November I visited New Orleans, under telegraphic orders from Major Howell, and there received verbal instructions from him to stop the manufacture and sinking of gabions, which orders I carried out on my return to Galveston, November 28, 1879.

Major Howell also gave me verbal instructions to put down mats made of brush and cane at the in-shore end of the Bolivar gabionnade.

These mattresses were made 18 by 60 feet, and about one foot thick over all. The cane or brush was laid one layer lengthwise, another crosswise, and another lengthwise, all held in place by frames of yellow pine, above and below fastened together with iron bolts, wooden pins, and galvanized iron wire.

A few mattresses 18 by 30 feet and 1 foot thick, made in a similar manner, were also used.

The larger mats were loaded with 100 concrete blocks. The blocks were the same as those used in weighting the mats placed under the gabions. They are about 30 by 18 by 6 inches, equal to 1⅞ cubic feet, with an average weight of 230 pounds, making the total weight of blocks on each mat 23,000 pounds.

During the month of December 30 of the larger and 4 of the smaller mattresses were placed in position.

As there was a deep trench along the line of the gabionnade, an offset of 114 feet to the northward was made as soon as the line of mattresses met the gabions, in order to avoid this trench. The mattress line was then continued parallel to the line of the gabionnade.

During the month of January 31 mattresses were sunk, 28 of the larger and 3 of the smaller size.

During the month of February 27 mattresses of the larger and 4 of the smaller size were sunk.

Under date of February 4, 1880, Mr. Ripley, United States assistant engineer, reported as follows:

"I have the honor to report that during Sunday's storm there were a number of mattresses dislodged from the jetty. Three are broken to pieces, and the lumber and cane are strewn along the beach south of the range. Two are still in the water only a short distance from the jetty on the south side. Their positions are shown by the ends of the cane projecting above the water. Apparently one end of each is relieved of the concrete blocks, which allows it to come up to near the surface of the water, the ends of the cane projecting above it. About ¼ of 1 of the 3 broken ones lies near the water's edge, and has 9 blocks upon it. These mattresses all came from near the inner end of the jetty, as I can tell by the lumber in the frames. The cook on the clam-shell dredge reports that on Sunday he saw 5 mattresses drift past the dredge toward the harbor.

"Shortly after your arrival the sinking of these mattresses was discontinued, since which time no examination has been made."

Repairs to the plant, wharves, buildings, etc., were made during the year, the details of which will be found in the report of the operations of the construction-yard.

SURVEYS AND EXAMINATIONS.

During the year surveys of the outer and inner bars and examinations of the line of the Bolivar gabionnade were made at times favorable for such work. A complete survey of the outer and inner bars was made in the month of August, 1879.

A comparison of the inner-bar portion with the survey made the preceding April showed that no material change had taken place. There was a practicable channel of 20½ feet depth with a least width of 500 feet on the inner bar, and 400 feet wide inside the bar between the 20-foot contour-lines.

A comparison of the survey of the outer bar with that made in the month of June pre-

ceding showed considerable change, especially immediately in front of the Bolivar channel, where a shoaling from ½ to 1 foot was found. A severe northeasterly storm occurred on the 23d and 24th of August, and the soundings upon this portion of the bar were taken on the 25th, so the change was undoubtedly due to this storm and the shoaling was subsequently found to have disappeared, and as no complaints were heard from ship-masters or pilots it is probable the shoaling was of very short duration.

A survey of the outer bar was made in November and December. On comparing this chart with those previously made, no material change was found to have taken place.

Examinations of the Bolivar gabionnade were made in July, September, and November, for the purpose of noting the changes that had taken place in the positions of the gabions.

These examinations, some of which were quite extensive and included the whole line, were reported upon at the time to Major Howell, and the reports will be found among the office records.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Captain of Engineers.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

B.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

BOLIVAR POINT, TEX., *July* 6, 1880.

CAPTAIN: I have the honor to submit the following report of operations for the improvement of Galveston Harbor, Texas, for the year ending June 30, 1880.

The journal herewith transmitted is of the usual form and shows the expenditure of material and labor, the construction of gabions, concrete blocks, mattresses, &c., the repairs to plant and other incidental work.

The progress made in gabionnade construction, together with detailed accounts of the behavior of the gabions and of changes shown by surveys, have already been reported. See reports dated August 1 and 22, September 12 and 20, November 17, 1879, and January 6, 1880. A description of mattress construction (mattress of brush or cane, with stiff wooden frames), together with a tracing showing manner of placing mattresses and their behavior, has also been furnished. See report dated March 4, 1880.

After the arrival of Colonel Mansfield, who had relieved Major Howell in charge of this work, the construction of mattresses with frames of wood was discontinued, and since that time our work has been to a great extent experimental. Under Colonel Mansfield's direction mattresses have been constructed after the manner of the Dutch in the improvement of the river Maas.

A brief description of our experiments with this form of mattress will now be given. A mattress 18 by 30 by 1.5 feet, made wholly of cane, was placed in the water and weighted with concrete blocks until it sunk to the bottom; 92 blocks were required to barely sink it and 100 blocks were necessary to hold it firmly upon the bottom. The weight of 100 blocks is about 23,000 pounds, which shows that it required 28½ pounds of stone to overcome the buoyancy of each cubic foot of mattress. The result of this experiment was deemed sufficient to condemn the use of cane for the bulk of the mattress; for, the cane being hollow and air-tight, it is believed that its buoyancy would not be greatly diminished by getting water-soaked, and hence as one of the constituents of the jetty it could never prove economical.

A second mattress 18 by 30 by 1.5 feet, made of brush with cane fascines, ropes and hurdle, was placed in the water and attached to the stem of the dredge-boat which is moored off the wharf in about 7 feet of water. This mattress sunk in about one week of its own accord and became so firmly attached to the bottom as to hold the dredge-boat against a strong wind and tide until finally the line was broken and the dredge swung to her anchor. Two mattresses 18 by 30 by 1.5 feet were next placed on the line of the north jetty at the outer end of the gabionnade. From the mattress in the bay sinking of its own accord, it was believed that only a few concrete blocks would be necessary to sink them; but these 2 mattresses had been made some time, and the brush of which they were composed had become thoroughly dried so that its buoyancy was much greater than had been anticipated, so that it was found after the mattresses were launched that there were barely blocks enough to sink them. The edge of one mattress lodged on the end of a gabion in sinking, and the sinking lines being too weak to raise it, before it could be dislodged the blocks from that edge had rolled down

towards the lower side of the mattress. The other mattress was capsized in launching from the barge, so that the hurdles which were intended to keep the blocks from being washed off the mattress were on the under side, and hence of no use.

After a fruitless effort to turn the mattress right side up, it being quite late and the sea increasing, the blocks were placed upon it and it was lowered to the bottom. It was then too late and the tide was too strong to bring the barges in, so they were moored near by and left. The sea increased during the night to such an extent that one of the barges broke away from her mooring by tearing away the gypsy from the sampson-post. It was with great difficulty next morning that men could get from the tug to the remaining barge to raise the anchor, on account of the sea.

I have been thus minute in the description of the placing of these two mattresses and of the condition of the weather because two days later, after the sea had subsided, it was found that they had been carried away. Eighty blocks had been placed upon them, which is equivalent to 11¼ pounds per cubic foot of mattress. The cause of the series of accidents above enumerated was due to inexperience as to necessary strength of sinking-lines, amount of ballast needed, mode of launching, &c.

Two days later two more mattresses of the same size were placed at the same point without a single accident. These were placed end to end across the line of the jetty and weighted with 125 blocks equivalent to 17¾ pounds per cubic foot of mattress. An examination made 17 days subsequent to their placing does not reveal any settlement even at their edges; neither is there shown any tendency to an accumulation of sand about them. Whether the sand has filled the interstices in the brush could not be determined. These mattresses were placed in about 14 feet of water—a deep scouring having taken place at the end of the gabionnade—which may be the cause of their failure to collect sand. At any rate the question can hardly be considered decided by the action of these two mattresses, placed as they are at the immediate end of the gabionnade.

A record of the tide and wind has been kept as heretofore by means of self-registering tide-gauge and anemometer, and a rain-gauge has been established since April. These records together with the record of the mean daily height of the barometer (obtained from the signal office, at Galveston) are being plotted so as to represent them graphically on a single chart. This chart is not yet finished, but will be furnished as soon as completed. A meter attachment has been made to the registering apparatus of the tide-gauge, so that a record of the velocity of the current is also kept. A description of the meter accompanies this report. The wind record has been plotted on diagrams which are herewith transmitted.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Capt. C. E. L. B. DAVIS,
Corps of Engineers U. S. A.

C.

PLANS AND ESTIMATES, REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

BOLIVAR POINT, TEX., *July* 3, 1880.

COLONEL: In accordance with your verbal instructions to prepare plans and estimates for the improvement of the entrance of Galveston Harbor, Texas, by means of jetties constructed after the manner of the Dutch in the improvement of the river Maas, I have the honor to submit the following report:

The accompanying tracings show the form and position of each jetty. The south jetty has a total length of 15,330 feet, and extends from the 6-foot contour at its inner end to the 13½ foot contour at its outer end. Commencing at the inner end for 4,080 feet, the top is 5 feet below the water surface and has a width of 12 feet. From this point the jetty slopes up to the water surface and gradually increases its width on top from 12 feet to 24 feet at a distance from the inner end of 10,220 feet.

From this point the top width is uniformly 24 feet, and the top is at the water surface for a distance of 14,960 feet from the inner end. From this point to the outer end, a distance of 370 feet, it gradually slopes down to the foundation mattress. The side slope is the same throughout for either side of the jetty, and has been assumed at 1 on 2, with a base berm projecting 10 feet beyond the intersection of the side slope and foundation mattress. Lest the width of this berm should prove insufficient on account of unexpected scour, an allowance has been made in the "Résumé of Estimates" for an additional width of 5 feet on either side. The outer end of the jetty or "pier head" is essentially different in form from that of the Maas jetty. It is believed, however, that different conditions, together with diminished cost, warrant the modification. All heavy seas must come from the Gulf, and will strike the jetty directly in end or at a small angle. A gently sloping face well paved to a depth of 8 feet will undoubtedly receive less shock than an enlarged and more abrupt pier head. Should experience during the course of construction prove its necessity, a less side slope can be given to the

jetty at its head so as to increase its bottom width at its highest point to, say, 400 feet instead of 90 feet, and the side could be paved as is shown on the end slope. This can be accomplished at a small additional cost and would, I think, insure the jetty head against storms which would endanger less exposed portions of the jetty.

The pile construction supporting the railway is also different from that of the Maas jetty; but it is believed to possess greater strength and stiffness at a less cost. The estimate for pile-work contemplates that the timber shall be of oak throughout, and that the piles shall be covered with zinc, wherever they come in contact with the water, to protect them from the teredo. Two rows of piles 5 feet from center to center, with alternate pairs driven at an angle, as shown on the tracing, extend from section A to section F inclusive. From section G to section O inclusive, 4 rows of piles are contemplated, as are shown on the tracing in plan and section.

It is believed that the pile-work will be unnecessary for the purpose of "consolidating" the jetty, and hence may be dispensed with, unless it should be thought an economical auxiliary in construction.

The north jetty has a total length of 8,090 feet, and extends from near the outer end of the Bolivar gabionnade to the 12-foot contour across the bar. The inner end is at a point on a shoal where the clay formation comes to within about 6 feet of the water surface and where the gabions have shown little disposition to settle further than through the sand deposit which covers this substratum of clay. From this point the top of the jetty slopes up to the water surface and increases its width gradually from 12 feet to 24 feet at a distance of 2,260 feet. From this point to its outer end the top width of the jetty remains at 24 feet and the top lies in the water surface to within 300 feet of the end, from which point it gradually slopes down to the foundation mattress at the end.

Section A begins at the outer end of the gabionnade, and shows where the inner end of the jetty would be if it be thought unnecessary to carry it back to the shoal above mentioned. The pile-work consists of 4 rows of piles 6 feet apart, with the piles in each row 5 feet from center to center without walling or superstructure. They are only intended for the purpose of "consolidation." In other respects the details are similar to those for the south jetty.

Two estimates for each jetty are herewith submitted: one in which the structure is composed of a foundation mattress and stone only, and the other in which the structure is composed of a foundation mattress and alternate layers of hearting mattresses and stone—the top being paved in strict accordance with the Dutch method.

The side slope which has been assumed, it is believed is steeper than stone will take if thrown in and allowed to assume its own slope, and it is probable that 30 per cent. would not be too much to add to the estimate, for the increase due to the change of slope, if foundation mattresses and stone alone be used. This addition has been made in the "Résumé of Estimates."

It should be remarked that these estimates have been made on the basis of actual experience here in the kind of construction proposed, and it is believed that the estimate is a liberal one. The only element of uncertainty is the cost of construction, and this must always be an uncertain element in work of this kind, where the progress of the work is dependent upon the state of the weather.

In the adoption of the form of the profiles of the jetties we have been guided by the principle that, while the ebb current should be confined to a single channel across the bar, as little obstruction as possible should be placed to the admission of water into the bay during flood-tide. It was desirable to accomplish this result with a minimum amount of construction, and hence the inner ends of the jetties commence some distance from the shore. In case of the south jetty, it is believed that the opening between its inner end and the pile breakwater will be protected from scour during ebb-tide by the current from Galveston Channel, whose direction is such as to force the water in Bolivar Channel northward and prevent much tendency to spread southward until a point of the jetty some distance from its inner end is reached. About 2,000 feet from its inner end, where the first concentration of current against the jetty occurs, it would seem appropriate to raise the jetty to its full height; but inasmuch as a larger opening must be left for the admission of flood water into the bay, and the inner end seems to be the only available place for an opening, aside from the opening between the jetties, this portion of the jetty is raised only sufficiently to destroy the scouring force of the current, and its full height is delayed until a point on the bar is reached where the direction of the flood current is such that the jetty offers but little opposition to it. Then, too, during ebb-tide, this is the portion of the jetty most efficient in concentrating the current on the bar; for, after passing the gorge between Bolivar Point and Fort Point, the momentum of the water must render the tendency to immediate divergence comparatively small.

In case of the north jetty, it will be seen that the opening between its inner end and the shore is covered by a shoal extending from Bolivar Point along the north margin of Bolivar Channel, crossing the line of the jetty at its inner end.

This shoal acts the part of a drowned jetty. Its formation was undoubtedly due to an eddy caused by the setting in of flood-tide from the northeast while the current in

Bolivar Channel was still running ebb. Its maintenance, I think, is due to two causes: first, a littoral current in the Gulf setting westward—(the opinion of sea-faring men familiar with the Gulf currents is to the effect that a littoral current of greater or less velocity runs to the westward nine-tenths of the time); second, northerly winds, which, while they force the water out of the bay and cause high velocities, at the same time press the water of the Gulf against the north side of Bolivar Channel and prevent its water from diverging northward. Where the gabionnade crosses this shoal, compact, tenacious blue clay is found about 6 feet from the water surface covered with 3 feet of sand. The existence of a clay formation in the clear waters of the Gulf assures us of its ancient origin, and hence we should expect that the same forces which have formed this shoal and preserved it for a long period will continue its existence, for, if our theory of its formation and maintenance be true, the building of the jetties will not alter the conditions to the prejudice of the shoal. It would be useless, therefore, to place the inner end of the jetty nearer to the shore than the point proposed. The gradual slope from the inner end to the water surface is to conform to the gradually increasing tendency of the water to divergence, which must exist as the distance from the shoal is increased, and also to avoid an abrupt end, which would be likely to cause eddies and unnecessary scour.

The extreme height of the jetties is placed at the water surface of mean low-tide rather than at the height of high-tide, for the reason that the strongest ebb currents, and hence those from which the greatest scour is expected, occur after the water has fallen about one-half the distance from high-tide to low-tide (as is shown by the current meter curve for a point in the bay, and it is probable that at a point on the bar the strongest ebb-tide would be found at a stage of the tide much lower, since there must be considerable slope to the water surface with a strong current, which in a distance of 5 miles would make quite a difference in the height of the water surface), and hence any height of jetty in excess of the height of the water surface would not only be superfluous as a confining agent, but it would go to increase the obstruction to the entrance of flood water. For strict economy, therefore, we should place the height of the highest part of the jetty so low that the water surface during strong ebb currents would not fall below it.

In the expenditure of so large an amount of money as the building of these two jetties involves, the question naturally arises, What depth across the bar may be expected from the outlay? To give a complete and definite answer to this question must be freely admitted to be impossible; yet we think it can be shown beyond a reasonable doubt that there will result a sufficient depth to satisfy all present and prospective demands of the port.

We have the following data:

1. Area of interior basin	square miles..	451
2. Mean daily tide at Bolivar Point	feet..	1.1
3. Area of cross-section of gorge between Bolivar Point and Fort Point	square feet..	155,611
4. Hydraulic mean depth of section	feet..	17.3
5. Greatest depth in section	feet..	44
6. Area of profile of south jetty	square feet..	115,496
7. Area of profile of north jetty	square feet..	61,170
8. Area of discharge over south jetty	square feet..	35,750
9. Area of discharge over north jetty	square feet..	6,780
10. Area of discharge over shoal at inner end of south jetty	square feet..	24,330
11. Area of discharge over opening at inner end of north jetty	square feet..	55,370
12. Area of discharge between north and south jetties	square feet..	140,690

Now, without going into a refined mathematical discussion calling for exact data as to velocities, water slopes, and volume of discharge, which we do not possess, we will simply point to the fact that in the present condition, without jetties, there is maintained on the bar over the area between the two jetties a very constant depth of 11 feet, with an area of discharge of 140,690 square feet. The effect of the jetties will be to augment the discharge between them by an amount equal to the amount which now crosses the line of the proposed jetties and finds its way across the bar at other points. The area of this discharge is equal to the combined areas of the profiles of the jetties, which is 176,666 square feet. In the absence of current measurements to determine the amount which thus escapes we have to judge of its amount by its effect in maintaining certain depths upon those portions of the bar over which it passes. An inspection of the chart shows that the water crossing the north jetty is sufficient to maintain depths varying from 4 feet to 10½ feet. We will be safe in assuming the mean depth at 8 feet.

As compared with the discharge, therefore, between the jetties, it would be as 8 to 11, and the amount would be equivalent to an amount which would pass an area $\frac{8}{11}$ of the area of the north jetty, which is $61.170 \times \frac{8}{11} = 44.451$ square feet.

Over the line of the south jetty the discharge is much greater, being sufficient to maintain depths ranging from 6½ to 11 feet.

We will be well on the side of safety in taking the mean depth at 9 feet. As compared with the discharge between the jetties, therefore, it would be as 9 to 11, and the amount would be equivalent to an amount which would pass an area $\frac{9}{11}$ of the area of the south jetty, which is $115,496 \times \frac{9}{11} = 94,497$ square feet.

The augmentation, therefore, would be $44,451 + 94,497 = 138,948$ square feet, which is nearly equal to the present area of discharge between the proposed jetties, and hence the resulting area of discharge between the jetties will be nearly twice its present area. Since there can be no lateral enlargement there will result a mean depth of about 22 feet.

An hydraulic mean depth of $17\frac{3}{10}$ feet in the cross-section of the gorge between Bolivar Point and Fort Point gives an extreme depth of 44 feet. The conditions, however, are different in the gorge and on the bar, so that in the latter place we should not expect so great a difference between the mean and extreme depths; but since the minimum depth cannot be greater than the height of the jetty, and since the friction caused by the jetties themselves must prevent a uniformity of velocity throughout the section, hence we should look with confidence for an extreme depth of not less than 25 feet.

Thus far the subject of maintenance only has been considered, and since it is well known that a greater force is required to deepen than to maintain a channel the question arises as to how the deepening is to be effected. This subject, therefore, calls for some consideration. The area of the bay which serves as a reservoir is 451 square miles, and the average tide at Bolivar is 1.1 feet. It should be remarked that only a small portion of the bay is raised to this height in an ordinary tide (see Report of Chief of Engineers for 1877, Part I, page 463); but at times of storms or extraordinary tides the water in the bay is elevated several feet. During the storm of 1877 a careful record of the tide was kept. The bay was filled gradually to a height of $5\frac{2}{10}$ feet above the plane of mean low-tide. A sudden shifting of the wind to the north, from which point it blew with a high velocity, induced so rapid a discharge of the bay water that the surface was lowered $6\frac{1}{4}$ feet in twenty-three and a half hours. The resulting velocity of current was enormous, and there can be no doubt, had the jetties been constructed, that the scouring force would have been sufficient to have excavated a deep channel across the bar, even though the material had been clay instead of sand. During the storm of 1875 the surface of the bay was elevated $8\frac{1}{2}$ feet at Bolivar Point, and at the head of the bay it is reported to have been elevated from 12 to 15 feet. No record of the time occupied in its discharge was kept; but the force exerted upon the bar was sufficient to move the whole body of the bar in front of Bolivar Channel nearly half a mile seaward. But aside from these great storms, which occur periodically, there are during each year a number of occasions when, under the influence of strong northers, the surface of the bay is lowered in a few hours 2, 3, or more feet, and the resulting force of the current is undoubtedly sufficient, with the concentration which the jetties will give, to remove the unstable sand formation of which the bar is composed.

It must be evident from the foregoing that with the jetties constructed there will be excavated and maintained a channel across the bar of sufficient depth to satisfy every demand. But we have seen that a good deal of uncertainty exists as to the full extent of scour which will take place, and hence economy dictates that the construction should progress in such a manner as to encourage the greatest amount of scour in the proposed channel, and at the same time admit of a cessation when the desired depth is reached. If this course be pursued there are good reasons for hoping that the entire completion of both jetties will not be necessary. An examination of the current meter curve shows, and the history of the deepening of the inner bar proves, that but little scouring effect can be expected from the ordinary tidal currents; and an examination of the tide and wind chart shows that extraordinary discharge currents occur only during northerly winds; and an inspection of a chart showing the relation of the bay and Gulf, shows that strong discharge currents cannot occur with the wind lying between east and south. An inspection of the wind diagrams shows that the only strong winds which will induce a rapid discharge of the bay water are northerly ones. The only condition, therefore, when much scour can occur is when strong northerly winds, which force the water out of the bay, at the same time press the water of the Gulf against the north side of the channel, and prevent its water from diverging northward. This furnishes an explanation for the fact that no channel across the bar of any importance has ever existed lying anywhere north of the axis of Bolivar Channel: while, since official records, a number of good channels have existed the direction of whose axes varied from extreme east to extreme south.

There can be no doubt, therefore, that the south jetty is the important one, and should be constructed first. To avoid the scour which would be likely to occur at the end of any completed portion of the jetty, it would seem advisable to place the foundation mattresses throughout the entire length before the superstructure is commenced. By thus commencing at the bottom, and raising the height gradually, the jetty could

receive its top finish at any time whenever the channel depth should announce that sufficient height had been reached.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Bvt. Lieut. Col. S. M. MANSFIELD,
Major of Engineers, U. S. A.

ESTIMATES FOR SOUTH AND NORTH JETTIES IN SECTIONS, AS SHOWN ON THE ACCOMPANYING TRACING.

In the estimates 1 foot has been allowed for settlement and compression of foundation mattress, and ½ has been allowed for compression of hearting mattresses.

Estimates of south jetty.

Section.	Length. feet.	Foundation mattresses. Cubic feet.	Foundation mattresses. Cost at 6½ cents per cubic foot.	Stone. Cubic feet.	Stone. Cubic yards.	Stone. Cost at $4 per cubic yard.	Hearting mattresses. Cubic feet.	Hearting mattresses. Cost at 6½ cents per cubic foot.
A	1,000	59,400	$3,861	42,520	1,574.8	$6,299	5,723	$372
B	1,000	79,350	5,158	128,265	4,750.5	19,002	50,651	3,292
C	1,000	80,010	5,201	131,555	4,872.4	19,490	52,661	3,423
D	1,080	76,230	4,955	91,425	3,386.1	13,544	25,976	1,688
E	1,000	65,265	4,242	56,775	2,102.8	8,411	9,858	641
F	1,000	66,300	4,310	54,300	2,011.1	8,044	8,850	575
G	1,000	78,735	5,020	109,230	4,045.5	16,182	42,413	2,757
H	1,000	104,640	6,802	276,585	10,243.9	40,976	169,017	10,986
I	1,000	116,137	7,549	368,813	13,659.7	54,639	247,635	16,096
J	1,000	126,982	8,254	469,813	17,400.5	69,602	337,899	21,963
K	1,000	135,000	8,875	551,000	20,407.4	81,630	411,750	26,764
L	1,000	134,580	8,748	546,170	20,228.5	80,914	407,393	26,481
M	1,000	129,840	8,440	492,380	18,236.3	72,945	359,025	23,337
N	1,000	129,000	8,385	483,000	17,888.9	71,556	350,625	22,791
O	880	115,920	7,535	452,090	16,744.1	66,976	332,831	21,634
P	370	37,750	2,454	92,012	3,407.8	13,631	58,013	3,771
	15,330	1,535,139	99,789	4,345,933	160,960.3	643,841	2,870,820	186,571

Section.	Stone when hearting mattresses are used. Cubic feet.	Stone when hearting mattresses are used. Cubic yards.	Stone when hearting mattresses are used. Cost at $4 per cubic yard.	Cost of material. Without hearting mattresses.	Cost of material. With hearting mattresses.	Cost of construction at 2 cents per cubic foot. Without hearting mattresses.	Cost of construction at 2 cents per cubic foot. With hearting mattresses.
A	38,705	1,433.5	$5,734	$10,160	$9,967	$2,038	$2,077
B	94,498	3,499.9	14,000	24,160	22,450	4,152	4,490
C	96,448	3,572.2	14,289	24,691	22,913	4,231	4,582
D	74,108	2,744.7	10,979	18,499	17,622	3,353	3,526
E	50,203	1,859.4	7,438	12,653	12,321	2,441	2,507
F	48,400	1,792.6	7,170	12,354	12,055	2,412	2,471
G	80,955	2,998.3	11,993	21,202	19,770	3,759	4,042
H	163,907	6,070.6	24,282	47,778	42,070	7,625	8,751
I	203,723	7,545.3	30,181	62,188	53,826	9,699	11,350
J	244,547	9,057.3	36,229	77,856	66,446	11,936	14,189
K	276,500	10,240.7	40,963	90,505	76,602	13,720	16,465
L	274,575	10,169.4	40,678	89,662	75,907	13,615	16,331
M	253,030	9,371.5	37,486	81,385	69,263	12,444	14,838
N	249,250	9,231.5	36,926	79,941	68,102	12,240	14,578
O	230,203	8,526.0	34,104	74,511	63,273	11,360	13,579
P	53,337	1,975.4	7,902	16,085	14,127	2,595	2,982
	2,432,389	90,088.3	360,354	743,630	646,714	117,620	136,758

Estimates of south jetty—Continued.

Section.	Cost of material and construction.		Pile work.		Trestle work to reach inner end of jetty.		Total cost of jetty.	
	Without hearting mattresses.	With hearting mattresses.	Linear feet.	Cost.	Feet.	Cost at $5.30½ per running foot.	Without hearting mattresses.	With hearting mattresses.
A	$12,198	$12,044	1,000	$5,305	....	....	$17,503	$17,349
B	28,312	26,940	1,000	5,305	....	....	33,617	32,245
C	28,922	27,495	1,000	5,305	....	....	34,227	32,800
D	21,852	21,148	1,080	5,730	....	....	27,582	26,878
E	15,094	14,828	1,000	5,305	....	....	20,399	20,133
F	14,766	14,526	1,000	5,165	....	....	19,931	19,691
G	24,961	23,812	1,000	5,545	....	....	30,506	29,357
H	55,403	50,821	1,000	5,475	....	....	60,878	56,296
I	71,887	65,176	1,000	5,335	....	....	77,222	70,511
J	89,792	80,635	1,000	5,265	....	....	95,057	85,900
K	104,225	93,067	1,000	5,125	....	....	109,350	98,192
L	103,277	92,238	1,000	5,125	....	....	108,402	97,363
M	93,829	84,101	1,000	5,125	....	....	98,954	89,226
N	92,181	82,680	1,000	5,125	....	....	97,306	87,805
O	85,871	76,852	880	4,511	....	....	90,382	81,363
P	18,680	17,109	200	1,026	....	....	19,706	18,135
	861,250	783,472	15,160	79,772	7,000	$37,135	941,022	863,244

Summary of estimates for south jetty.

1,535,139 cubic feet foundation mattresses, at 6½ cents	$99,784
160,960.3 cubic yards stone, at $4	643,841
5,881,072 cubic feet construction, at 2 cents	117,621
15,160 linear feet pile-work in jetty	79,772
7,000 linear feet pile-work, at $5.30½	37,137
	978,155
Add 20 per cent. for contingencies, superintendence, &c	195,631
Total estimated cost of jetty	1,173,786

If hearting mattresses can be used, the summary will be as follows:

1,535,139 cubic feet foundation mattresses, at 6½ cents	$99,784
2,870,320 cubic feet hearting mattresses, at 6½ cents	186,571
90,088.4 cubic yards stone, at $4	360,354
6,837,848 cubic feet construction, at 2 cents	136,757
15,160 linear feet pile-work in jetty	79,772
7,000 linear feet pile-work to reach jetty, at $5.30½	37,135
	900,373
Add 20 per cent. for contingencies, superintendence, &c	180,075
Total estimated cost of jetty	1,080,448

Estimates for north jetty.

Section.	Length, feet.	Foundation mattresses. Cubic feet.	Foundation mattresses. Cost at 6½ cents per cubic foot.	Stone. Cubic feet.	Stone. Cubic yards.	Stone. Cost at $4 per cubic yard.	Hearting mattresses. Cubic feet.	Hearting mattresses. Cost at 6½ cents per cubic foot.
a	1,960	164,880	$10,717	310,867	11,513.6	$46,054	195,846	$12,730
A	300	28,350	1,843	54,500	2,018.5	8,074	34,335	2,232
B	530	62,910	4,089	199,120	7,374.8	29,499	135,842	8,830
C	1,000	118,050	7,673	369,325	13,678.7	54,715	250,797	16,302
D	1,000	124,320	8,081	433,180	16,043.7	64,175	306,564	19,927
E	1,000	134,430	8,738	510,595	18,910.9	75,644	375,443	24,404
F	1,000	138,060	8,974	552,280	20,454.8	81,819	413,036	26,847
G	1,000	135,840	8,830	526,160	19,487.4	77,950	389,340	25,307
H	300	30,600	1,989	74,000	2,740.7	10,963	46,620	3,030
	8,090	937,440	60,934	3,030,027	112,223.1	448,893	2,147,823	139,609

Section.	Stone when hearting mattresses are used. Cubic feet.	Stone when hearting mattresses are used. Cubic yards.	Stone when hearting mattresses are used. Cost at $4 per cubic yard.	Cost of material. Without hearting mattresses	Cost of material. With hearting mattresses.	Construction at two cents per cubic foot. Without hearting mattresses.	Construction at two cents per cubic foot. With hearting mattresses.	Total cost of jetty. Without hearting mattresses.	Total cost of jetty. With hearting mattresses.
a	180,308	6,677.9	$26,712	$56,771	$50,159	$9,515	$10,821	$66,286	$60,980
A	31,610	1,170.7	4,683	9,917	8,758	1,657	1,886	11,574	10,644
B	108,559	4,020.7	16,083	33,588	29,002	5,241	6,146	38,829	35,148
C	202,127	7,486.2	29,945	62,388	53,920	9,747	11,419	72,135	65,339
D	228,804	8,474.2	33,897	72,256	61,905	11,150	13,194	83,406	75,099
E	260,300	9,640.7	38,563	84,382	71,705	12,900	15,403	97,282	87,108
F	276,923	10,256.4	41,026	90,793	76,847	13,807	16,560	104,600	93,407
G	266,600	9,874.1	39,496	86,780	73,633	13,240	15,836	100,020	89,469
H	42,920	1,589.6	6,358	12,952	11,377	2,092	2,403	15,044	13,780
	1,598,146	59,190.5	236,763	509,827	437,306	79,349	93,668	589,176	530,974

Summary of estimates for north jetty.

937,440 cubic feet foundation mattresses, at 6½ cents	$60,934
112,223.1 cubic yards stone, at $4	448,892
3,967,467 cubic feet construction, at 2 cents	79,349
	589,175
Add 20 per cent. for contingencies, superintendence, &c	117,835
Total estimated cost of jetty	707,010

If hearting mattresses can be used, the summary will be as follows:

937,440 cubic feet foundation mattresses, at 6½ cents	$60,934
2,147,823 cubic feet hearting mattresses, at 6½ cents	139,609
59,190.5 cubic yards stone, at $4	236,762
4,683,409 cubic feet construction, at 2 cents	93,668
8,090 linear feet pile-work, at $2.20	17,798
	548,771
Add 20 per cent. for contingencies, superintendence, &c	109,754
Total estimated cost of jetty	658,525

RÉSUMÉ OF ESTIMATES.

Foundation mattresses and stone alone being used:

South jetty		$1,173,786
North jetty		707,010
		1,880,796
Add 30 per cent. for probable changes in side slope		564,239
		2,445,035
Add plant:		
1 tug-boat	$20,000	
2 barges, 100 by 40 feet	5,000	
6 barges, 100 by 40 feet	12,000	
4 barges, 80 by 30 feet	2,000	
Platform	1,000	
		40,000
Total estimated cost		2,495,035
Possible deductions:		
Pile-work, south jetty		116,907
Total		2,378,128

Foundation mattresses, hearting mattresses, and stone being used:

South jetty		$1,080,448
North jetty		658,525
For both jetties		1,738,973
Add for 10 feet increased width of foundation mattress, $2 per running foot.		46,840
Plant		40,000
Total cost		1,825,813
Possible deductions:		
Excessive compression allowed in the estimate	$71,090	
Pile-work, if it proves unnecessary	134,705	
If gabions on hand be used	42,726	
		248,521
Aggregate		1,577,292

Estimated cost per running foot for each foot depth of south jetty.

Depth in feet.	Foundation mattresses.		Hearting mattresses.		Stone.		Construction at 2 cents per cubic foot.	Total.
	Cubic feet.	Cost at 6½ cents per cubic foot.	Cubic feet.	Cost at 6½ cents.	Cubic yards.	Cost at $4.		
1	51	$3 32	....	....	0.63	$2 52	$1 36	$7 20
2	57	3 71	....	....	1.20	4 80	1 80	10 31
3	63	4 10	7.8	$0 51	1.77	7 08	2 48	14 17
4	69	4 49	19.5	1 27	2.00	8 00	3 31	17 07
5	75	4 88	53.4	3 47	2.57	10 28	4 67	23 30
6	81	5 27	84.3	5 48	2.99	11 96	6 05	28 76
7	96	6 24	116.3	7 56	4.98	19 92	8 50	42 22
8	103	6 70	159.6	10 37	5.91	23 64	10 56	51 27
9	110	7 15	207.2	13 47	6.92	27 68	12 76	61 06
10	120	7 80	275.6	17 91	8.01	32 04	15 91	73 60
11	128	8 32	340.2	22 11	9.12	36 48	18 81	85 72
12	135	8 78	411.8	26 77	10 24	40 96	21 84	98 35

NOTE.—The height of the structure is 1 foot greater than is shown in the first column, this amount having been allowed for settlement.

D.

ANALYSIS OF CURRENT METER REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

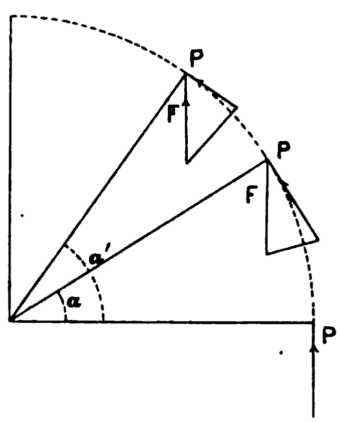
BOLIVAR POINT, TEX., *June* 30, 1880.

CAPTAIN: I have the honor to submit the following analysis of a current meter together with some remarks concerning velocities of the current during the ebb and flow of the tide.

It must have occurred to every one who has made the subject of harbor improvements a study that, while the subject of tides, as regards rise and fall and duration, has been exhaustively investigated and discussed, the more important consideration of velocities has been most woefully neglected.

In the consideration of the improvement of the entrance to a tidal harbor the most important factor is the velocities of the tidal currents. For the purpose of determining this element of tidal phenomena, I have devised a current meter, which is attached to a self-registering tide gauge, and by this means a continuous record of the velocities, as well as the rise and fall of the tide, is obtained.

The meter consists of a vertical shaft, free to revolve horizontally, extending from near the bottom up into the house where is placed the recording apparatus. At a point on the shaft midway between the bottom and the surface of the water at mean low-tide, an arm projects at right angles to the shaft, upon the outer end of which is a flat disk or vane so placed as to receive the pressure of the current upon its face. Near the upper end of the vertical shaft are placed three horizontal circular disks, upon the peripheries of which are grooves, which admit small cords, which pass around them. To two of the cords are attached counter weights so adjusted as to tend to keep the arm, with its vane, at right angles to the direction of the current. To the third cord is attached a small weight, after it has passed over a pulley near the recording apparatus, and by means of a pencil also attached to this cord, and moving along the roll of paper in the recording apparatus, the angular movement of the vertical shaft is recorded. The record thus made is a curve, of which the abscissas are in time, and the ordinates are functions of the angular movements of the vertical shaft. In fact they are the development of portions of the circular disk around which the cord which carries the pencil passes, and their lengths are determined by the angular movements of the vertical shaft. It becomes necessary, therefore, to determine the relation of the velocity of the current to the lengths of the ordinates of the meter curve.



Let F = the force of the current, and
Let P = the component of pressure perpendicular to the plane of the vane.
Let a and a' = the angles of deflection corresponding to the forces F and F'.
Let V and V' = velocities of the current corresponding to F and F' or a and a'.
We have (see Trautwine, page 571)—

$$V^2 : V'^2 :: F : F'.$$

But

$$F = \frac{P}{\cos a} \text{ and } F' = \frac{P}{\cos a'}$$

Hence

$$V^2 : V'^2 :: \frac{P}{\cos a} : \frac{P}{\cos a'}$$

$$V^2 = \frac{V'^2 \cos a'}{\cos a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The size of the circular disk which governs the movement of the pencil is such that a movement of the vane through an arc of 20° gives an ordinate to the meter curve equal to 1 inch. If, therefore, we represent any ordinate of the curve by a, and the particular ordinate corresponding to a' by a', we shall have

$a = 20° \times a$ and $a' = 20° \times a'$ and eq. (1) becomes

$$V^2 = \frac{V'^2 \cos (20° \times a)}{\cos (20° \times a')} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From a single observation, or the mean of a number of observations, we can determine the value of V′, and by noting the corresponding value of a' we can reduce the numerator of the second number of eq. (2) to a constant of simple form. In case of the instrument now in operation,

$$V'^2 \cos (20° \times a') = .642,$$

Which reduces eq. (2) to the form

$$V^2 = \frac{.642}{\cos (20° \times a)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

It is a simple matter, therefore, to find the value of V from eq. (3). By finding the value of V for various values of a, we can construct a scale by means of which the value of V can be determined at once by taking the measure of a from the meter curve and applying it to the scale. This will give the value of V in feet per second or miles per hour, according as V′ was determined in feet per second or miles per hour.

If $a = 0$ eq. (3) becomes

$$V^2 = \frac{.642}{\cos 0°} = .642 \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and V = .80125 foot per second, which shows that it requires a velocity of .80125 foot per second to equilibrate the counter-weight, and hence any velocity smaller than $\frac{8}{10}$ of a foot per second will not be registered. In the practical working of the instrument a slight stretching of the cord allows the pencil to move slightly to one side or the other of the slack tide-line, and so indicates whether the tide is running flood or ebb. One advantage of this meter is its absolute freedom from an element of friction, provided, of course, that the friction of the parts are not far beyond the possibilities of easy construction. As have been shown by the records of this apparatus, there is a succession of impulses in the current sufficient to overcome all ordinary or necessary friction. The meter curve is not a closely-defined line, but a heavy shaded one, showing a continued oscillation of the vane through a small arc.

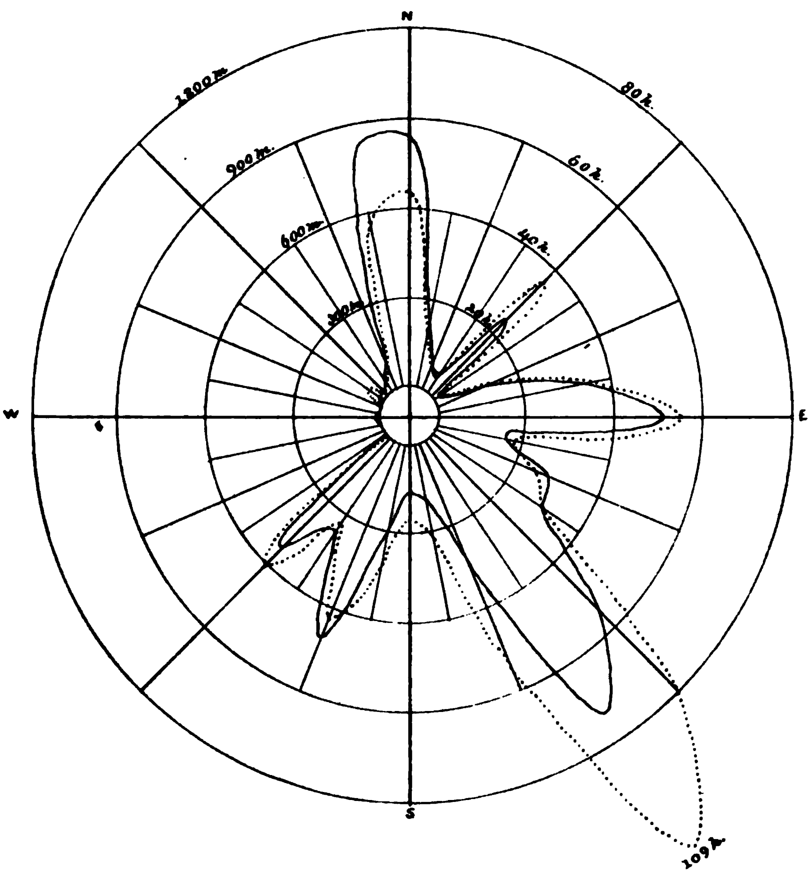
The friction then would only tend to diminish this oscillation, and the center of the heavy shaded line would give the absolute velocity of the current, the friction of the apparatus having been eliminated. One disadvantage of the instrument is its inability to record a great range of velocities. To measure a very small velocity it is necessary to increase the proportion of the size of the vane to the counter-weights. But for the purpose for which it is here used small velocities are unimportant so long as they are known to be such.

Herewith transmitted is a specimen of the record for a half nodical period from the descending node April 21, 6 p. m., to the ascending node May 4, 9.35 a. m. The record for any other similar period gives a similar curve, although possessing peculiarities of its own. The curve here presented is a characteristic one, and furnishes information about the tides which it would not be easy to obtain by other means. In discussing this curve, however, it should be remembered that the location of the meter is not the most favorable one for obtaining high velocities, and it is possible that if placed upon the bar or in Bolivar Channel the curve would show characteristics not shown in the present location of the meter. Its present location is in the bay at one side of the wharf, in about 6 feet of water and about 200 feet from the shore. The current to reach the meter has to pass over a shoal with but 3 to 4 feet depth of water and through the piling of the wharf.

After making all due allowance, however, for the defective location of the meter, yet we have an interesting and instructive record. It will be seen that for about one-fifth of the time (near the node) there is no current exceeding eight-tenths of a foot per second; but that midway between the nodes the currents are much stronger. More particularly, however, will be noticed the short duration and strength of the ebb currents compared to long duration and weakness of the flood currents. It will further

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.



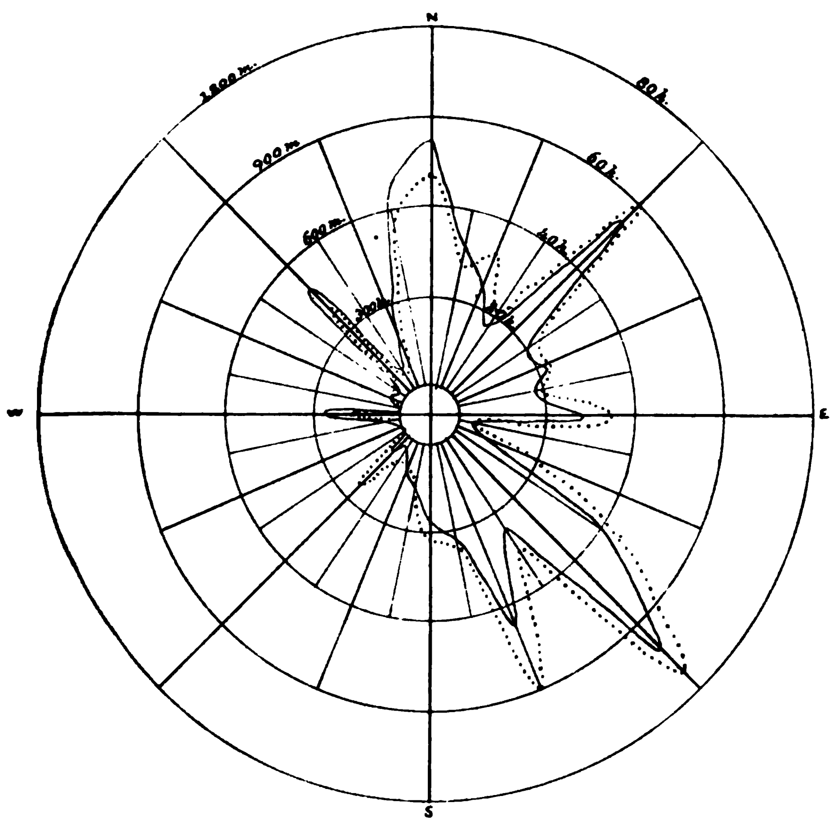
JANUARY, 1880.

Distance traveled from all directions	9,832 m.
Total hours	738
Mean velocity per hour	13.3 m.

Record of 6 hours lost.

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

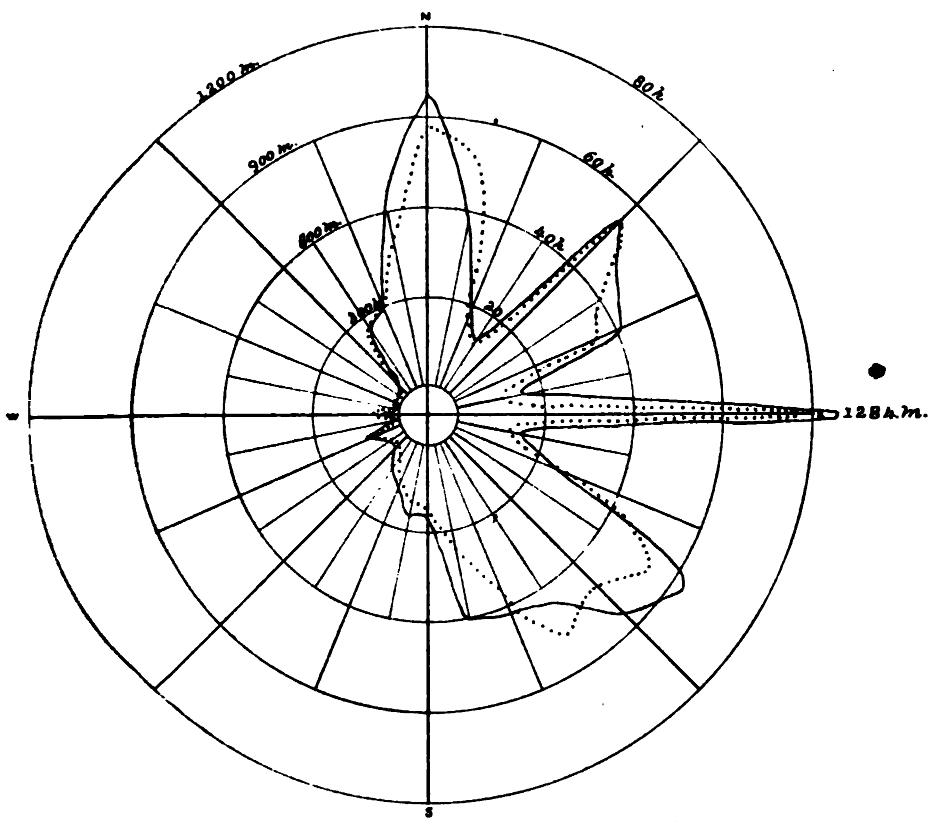


FEBRUARY, 1880.

Distance traveled from all directions........................	9,664 m.
Total hours..	692
Mean velocity per hour..................................	13.96 m.
Record of 4 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

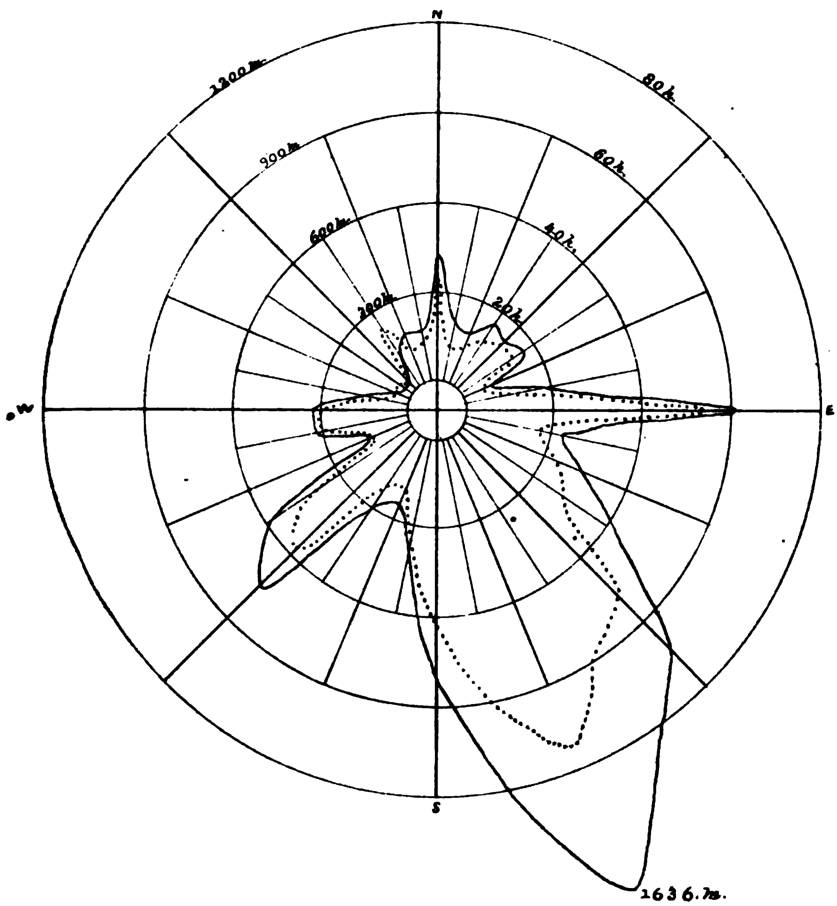


MARCH, 1880.

Distance traveled from all directions	**12,487 m.**
Total hours	**743**
Mean velocity per hour	**16.8 m.**
Record of 1 hour lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

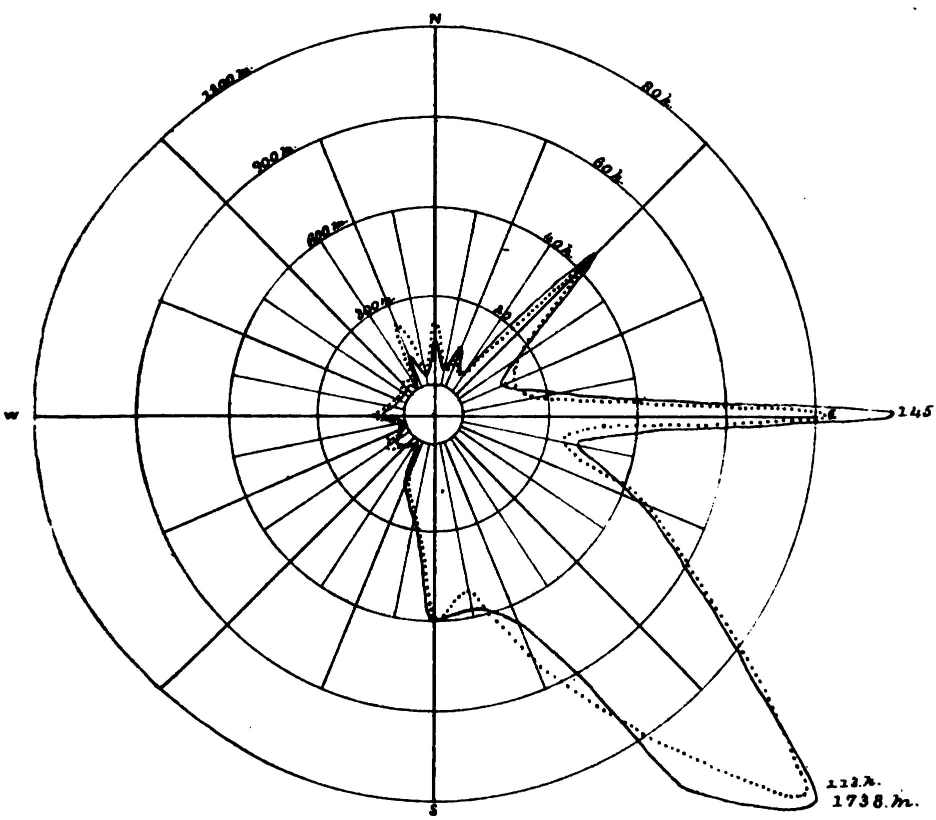


APRIL, 1880.

Distance traveled from all directions	13,814 m.
Total hours	720
Mean velocity per hour	19.18 m.

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

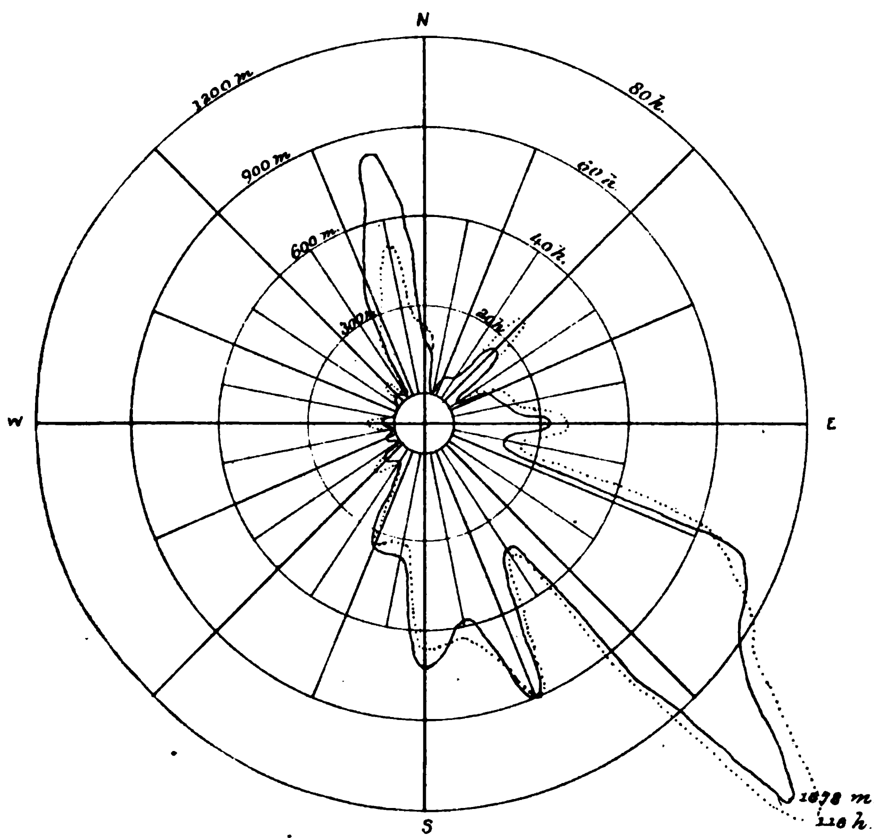


MAY, 1880.

Distance traveled from all directions	**11,145 m.**
Total hours	**732**
Mean velocity per hour	**15.22 m.**
Record of 12 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

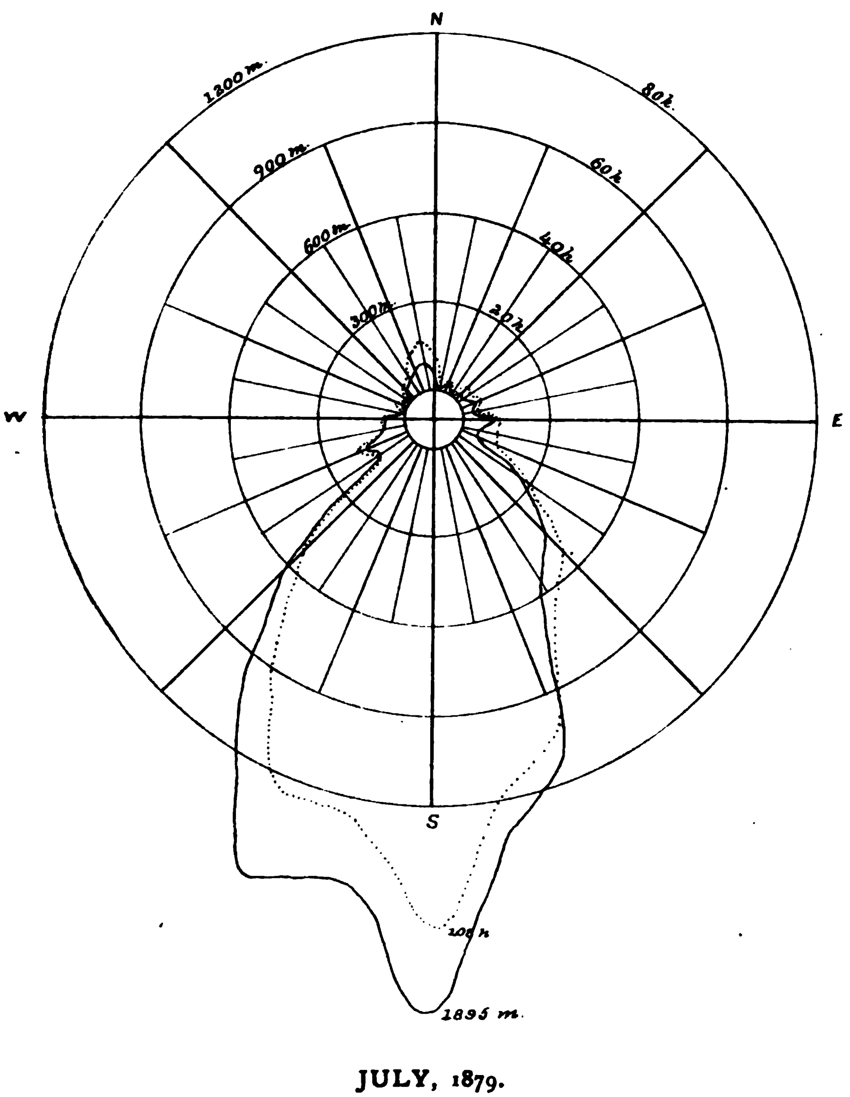


JUNE, 1879.

Distance traveled from all directions	10,289 m.
Total hours	695
Mean velocity per hour	14.8 m.
Record of 25 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

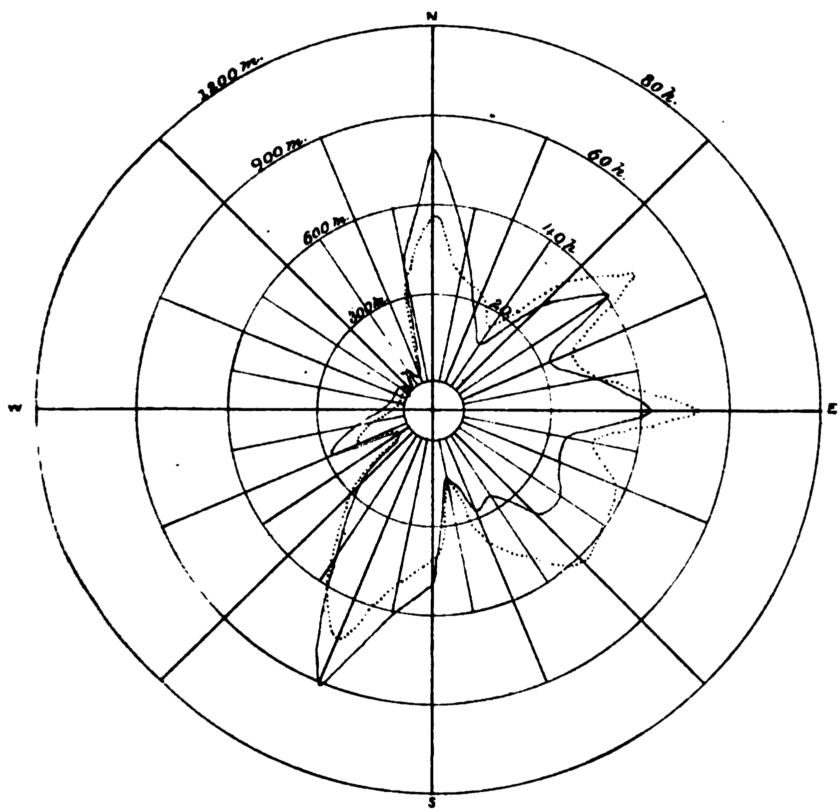


JULY, 1879.

Distance traveled from all directions	11,471 m.
Total hours	724
Mean velocity per hour	15.84 m.
Record of 20 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

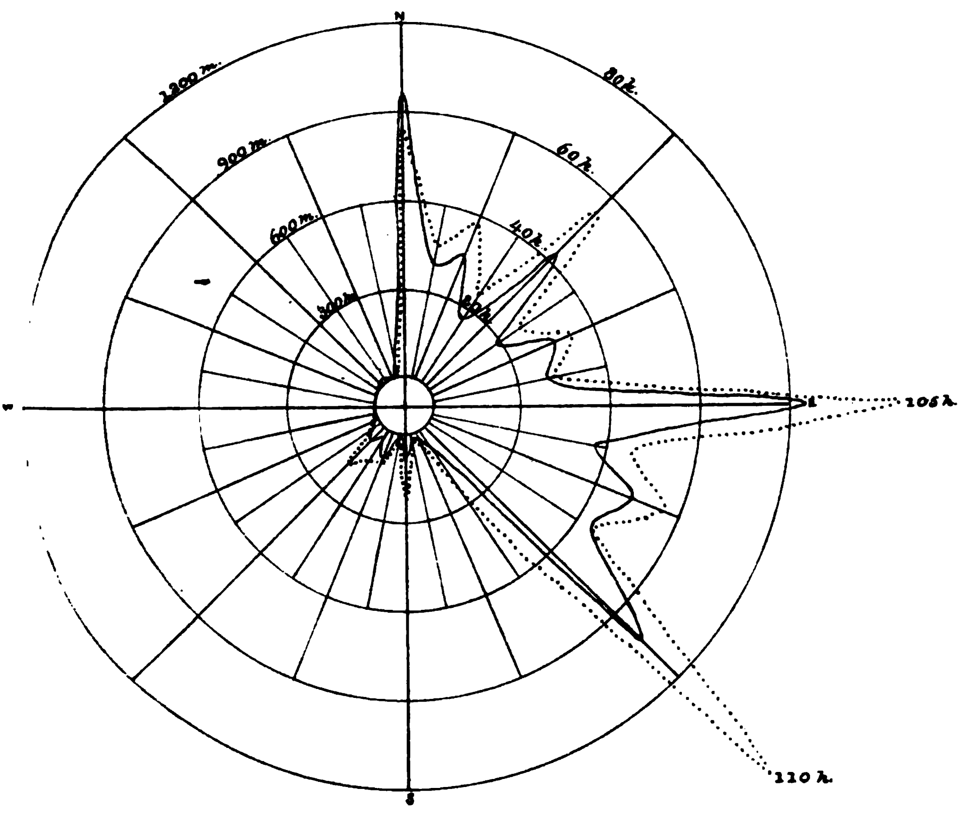


AUGUST, 1879.

Distance traveled from all directions	**10, 388 m.**
Total hours	**741**
Mean velocity per hour	**14.02 m.**
Record of 3 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

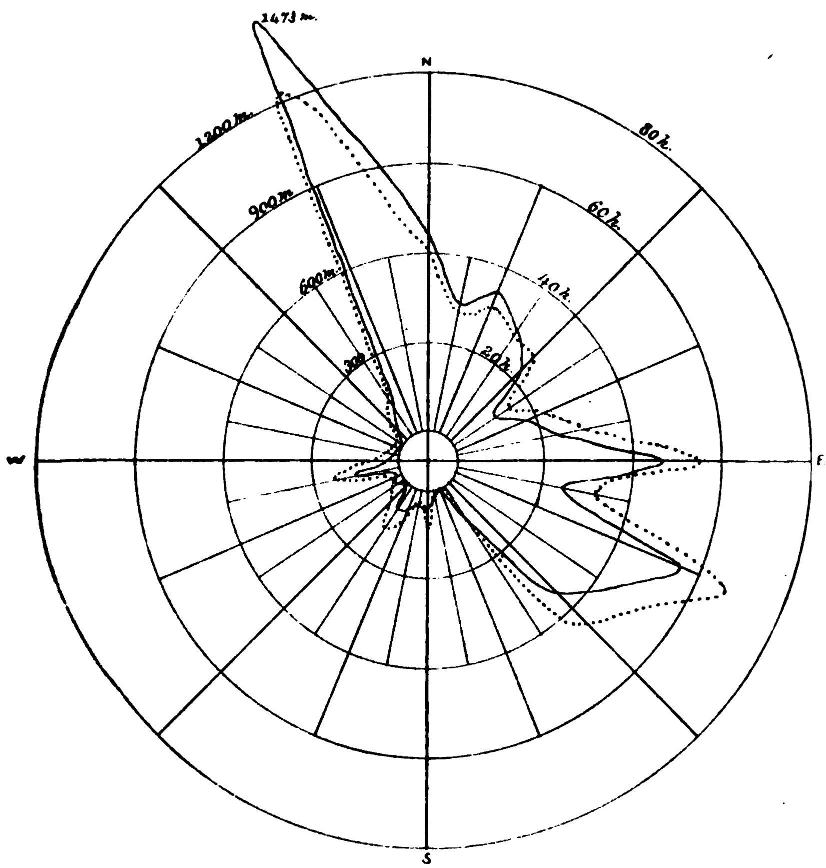


SEPTEMBER, 1879.

Distance traveled from all directions	8,683 m.
Total hours	720
Mean velocity per hour	12.17 m.

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

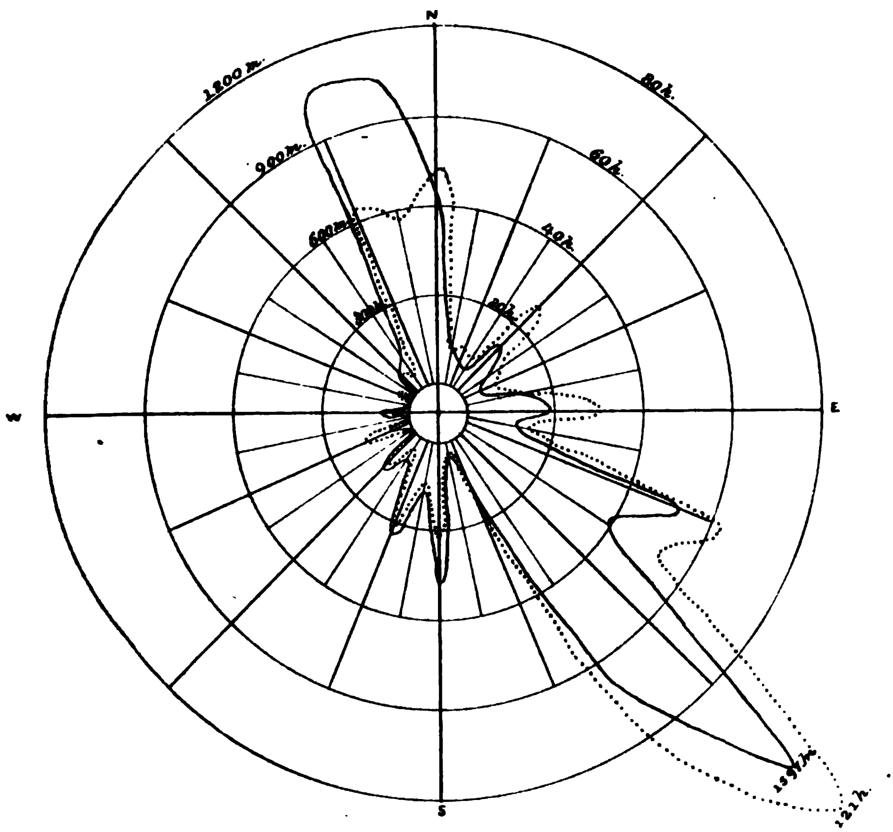


OCTOBER, 1879.

Distance traveled from all directions	**9,738 m.**
Total hours	**714**
Mean velocity per hour	**13.63 m.**
Record of 30 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

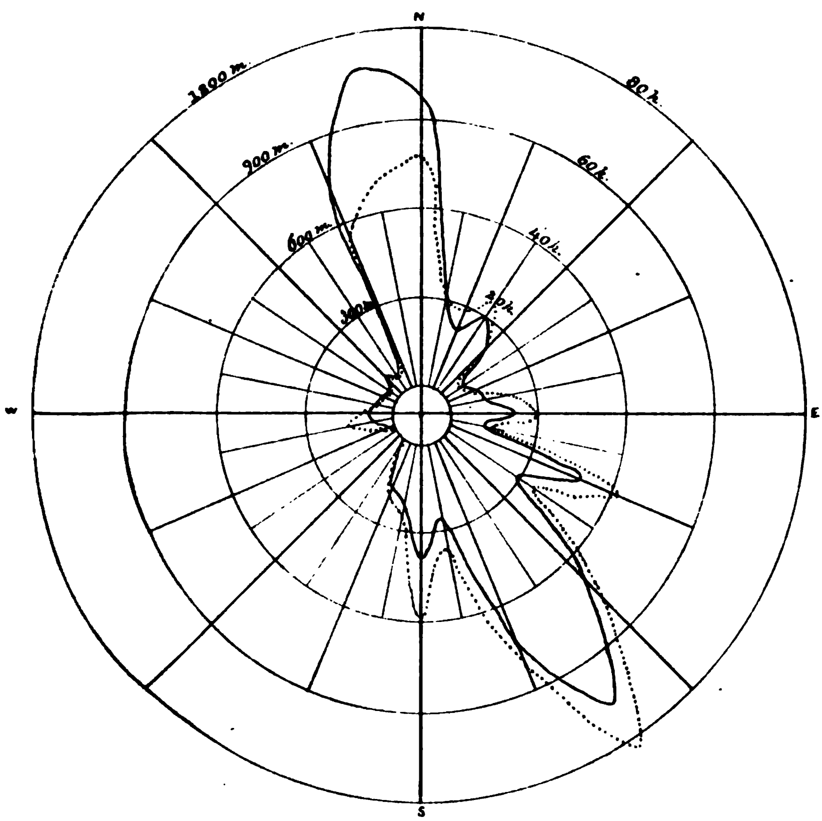


NOVEMBER, 1879.

Distance traveled from all directions	9,903 m.
Total hours	690
Mean velocity per hour	14.35 m.
Record of 30 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

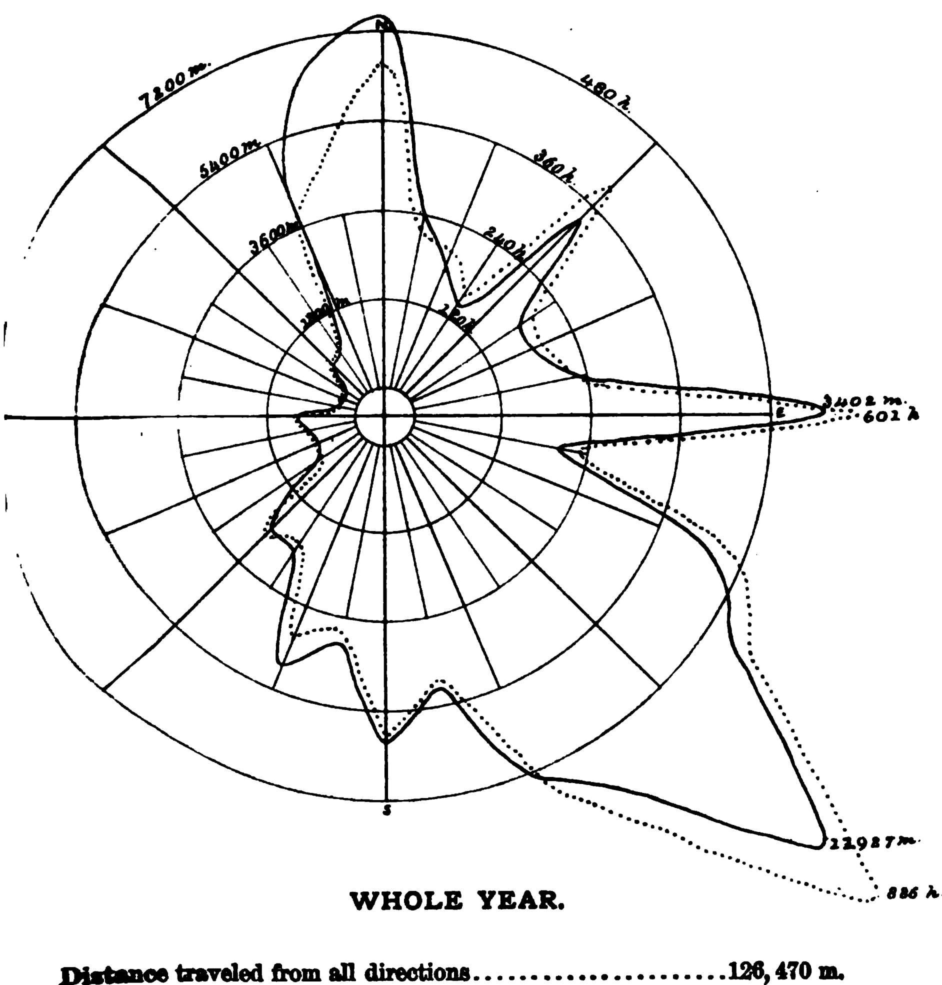


DECEMBER, 1879.

Distance traveled from all directions	9,056 m.
Total hours	637
Mean velocity per hour	14.2 m.
Record of 107 hours lost.	

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The full line shows the quantity of wind, and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours; the circumference of the small circle at the center of the compass rose being the zero of the scale.

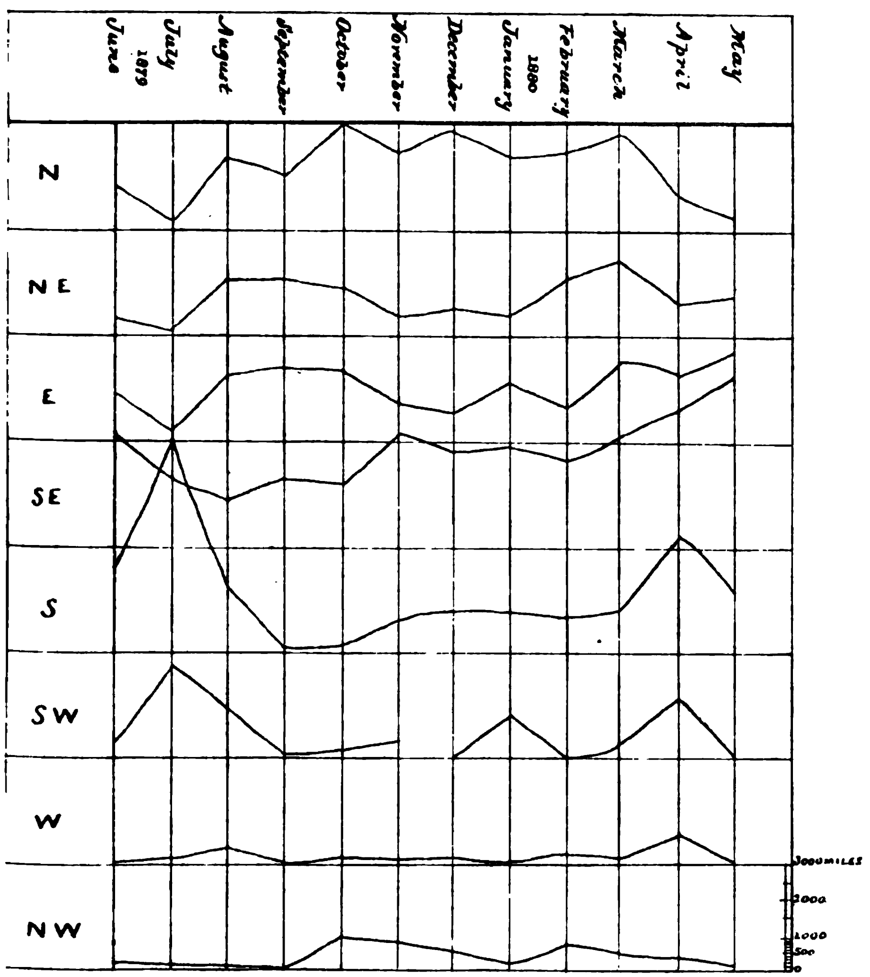


WHOLE YEAR.

Distance traveled from all directions........................126,470 m.
Total hours.. 8,546
Mean velocity per hour.. 14.79 m.
Record of 238 hours lost.

DIAGRAM OF WIND AT GALVESTON HARBOR, TEXAS.

The ordinates show the quantity of wind in miles, and the abscissas show the time in months.



1879. —— 1880.

be observed that the ebb current attains its maximum velocity when the tide has reached a stage about half way between high tide and low tide, and that the current continues strong until low tide is reached, and that it still continues running ebb for a short time (with less strength) after the tide has commenced to rise. With regard to the flood tide, it will be seen that the duration of high velocities is very short, while a moderate velocity continues many hours. A very interesting peculiarity of the tidal current is here well illustrated, and that is the sudden changes in velocity which occur repeatedly. These pulsations are not confined to either stage of tide, but are more numerous during flood than during ebb tide.

This same peculiarity has been noticed at San Francisco Harbor by Lieutenant Payson. (See Report of Chief of Engineers for 1878, Part II, page 1317.) A curious and somewhat exceptional behavior of the tide is exhibited by the curve for the 29th of April, at about 10 a. m. The tide was rising rapidly when suddenly a strong ebb current was set up, which lasted for about an hour without any apparent cessation in the rising of the tide.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Capt. C. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

E.

DIAGRAMS OF WIND AT GALVESTON HARBOR, TEXAS, FROM JUNE, 1879, TO MAY, 1880, INCLUSIVE.

The full line shows the quantity of wind and the dotted line shows the corresponding time. The scale for the wind is in miles and for the time is in hours—the circumference of the small circle at the center of the compass rose being the zero of the scale.

Upon the rectangular diagram the ordinates show the quantity of wind in miles, and the abscissas show the time in months.

REPORT OF THE BOARD OF ENGINEERS.

ARMY BUILDING,
New York, June 7, 1880.

GENERAL: By department letter of March 30, 1880, there were transmitted to the Board constituted by Special Orders 63, Headquarters Corps of Engineers, series of 1879, for its consideration in connection with the recommendations made in its report of August 9, 1879, upon Galveston Harbor piers, Major Mansfield's letter of March 25, 1880, and that of his assistant, Mr. Ripley, of March 22, setting forth and recommending a method for disposing of all cement gabions now on hand. This reference virtually opens the whole question of the improvement of the entrance to Galveston Harbor, and involves an analysis of the methods hitherto used in constructing the piers, as well as determinate recommendations as to processes advisable for their future construction.

The project for improving the entrance to Galveston Harbor, Texas, as devised by Major Howell in 1873, had for its object the removal of the inner bar between Fort Point and Pelican Spit, and deepening the outer or Gulf bar from 12 to 18 feet, possibly.

The first he proposed to effect by continuing the city dike to the northeast to the verge of the Bolivar or Cylinder Channel, thus causing a contraction of the water-way over the inner bar, sufficient to remove it by the scouring process. The second, by prolonging this dike directed seaward to the outer slope of the Gulf bar, and by constructing a similar and parallel dike from Bolivar Point seaward.

As there were at that time no stone quarries opened or known in

Texas, accessible by railroad or by navigable water routes, and as transportation from the north was very costly, Major Howell devised and proposed the use of a gabion, covered on the inside and outside with hydraulic cement, to be filled with sand, to take the place of stone in the construction of the projected piers. He thus describes his system in his report of December, 1873:

The jetties are to be made of cement-covered gabions. The gabions are to be 6 feet in diameter and 6 feet high, two rows in each jetty; all to be fastened together by copper wire at the tops, and filled with sand by a dredge-boat alongside as they are placed in position. They may be called submerged jetties, since they will not, except on a short portion of their lines, be built up to the plane of mean low tide, while for the greater part their tops will be 5 or 6 feet below that plane.

The present area of discharge over the bar is 411,184.25 square feet. The contracted area will be 274,112 square feet, the former measured along the crest of the bar, and the latter along the jetties and that portion of the crest between them.

The jetties are expected to act as training-walls for the lower ebb current, while the upper will pass over them. They are calculated to give a depth on the outer bar of between 18 and 19 feet, and at the same time only confine and direct so much of the ebb and flood currents as may be useful, thus preventing as great advance of the bar gulfward as might be expected, were the jetties built up to the plane of mean low-tide; further, making them less exposed to the destructive action of storms, giving them less weight to sink them into the unstable material offered for a foundation, and making them less expensive.

It is thought these jetties will serve to catch the drifting sand brought by the littoral currents until they are covered by it, and that afterwards the sand will be carried over them rather than around their ends.

This project referred in January, 1874, by the Chief of Engineers for consideration and report to a special Board (S. O. 9, 1874) was approved as to the general plan, though doubts were expressed as to the successful use of the cemented gabion—the specialty of the project. (See report dated January 31, 1874.) In fact, it was not thought that the gabion would be a success unless covered by drift sand, as anticipated by Major Howell. As, however, economy of construction, the apparent merit of the proposed plan, depended upon the use of the gabion, its trial was recommended, first, in the Fort Point Jetty, commencing at its junction with the city dike, afterwards on the shore end of the Bolivar Jetty, and finally in the construction of 300 to 500 feet of its outer end on the most exposed portion of the Gulf Bar.

The first trial of the cemented gabions was made in November, 1874, nineteen of which were set in prolongation of the city dike. These were exposed to a severe storm during the 4th, 5th, and 6th days of December, without being displaced or injured. In fact, they were nearly buried by drift sand. The engineer in charge of the construction looked upon this test as establishing the gabion structure as a success, and in consequence the subject was referred back to the Galveston Harbor Board for their opinion thereon. That Board, however, did not regard the test sufficient, and therefore reiterated their opinion that the full trials recommended in their report of January, 1874, should be carried out.

From December, 1874, until the 14th of September, 1875, work on the Fort Point jetty was continued under the direct and active supervision of Lieutenant Quinn, during which time 530 gabions were placed, and about 1,200 feet length of breakwater constructed. It was found necessary to place the gabions in two rows, connected by cross-walls and supported on the channel side by frequent short spur-dikes.

Thus placed, drift sand was collected and undermining prevented; but the system consumed nearly as many gabions as four rows side by side would have done.

It was, however, a difficult position in many respects, and especially on account of the rapid rush of the current along the inner face of the

breakwater; and to these adverse conditions the large number of gabions used and greater cost of structure were due—conditions against which it would have been necessary to provide had any other kind of breakwater been attempted in that position.

The almost unprecedented gale of the 14th, 15th, and 16th of September, 1875, destroyed nearly all the plant and material on hand, causing a loss estimated at $50,000. Some marked changes in shore lines and channels were produced by the storm, a large portion of the city dike destroyed, and all more or less damaged.

In December following the project of the Galveston improvement was referred back to the Board for reconsideration, and for modification should it be deemed necessary, in view of the damages and changes produced by the gale. It appeared, however, from examination that the gabionnade thus far built had been entirely covered with drift sand and had thus escaped injury, and that no changes had occurred in channels, shore lines, &c., of sufficient importance to necessitate any change in the project or methods of construction. The Board therefore advised no modification of plan, but reiterated their former recommendation in reference thereto. Though the test of the gabion had been satisfactory so far as applied, they were careful to say that it "should not be adopted definitively for the main works" until subjected to all the tests prescribed in their previous reports, adding their opinion that—

> The use of these gabions in exposed situations can be attended with success only in case they shall be soon covered by the drifting sands, so as to protect them from injury from the continued action of waves, from the shock of floating bodies, and from all other causes which might tend to disrupt them and allow their sand filling to escape. When so protected they will form a nucleus for the sand ridges as stable and as permanent as if of stone or concrete. But if not so protected, these gabion structures will be constantly liable to injury and in time to decay, when, losing their sand filling, the structure would soon be washed away. That the proposed jetties will be so covered seems probable, but can be determined only by trial such as we have recommended.

In the spring of 1876, the plant destroyed by the storm of September, 1875, was replaced and a new depot on Bolivar Point established, where large quantities of material were collected and prepared for resuming the the construction of the jetties.

The expenditures for the above purposes consumed the balance of the second appropriation and caused cessation of work early in July. With the third appropriation, which did not become fully available until February 22, 1877, the city dike, destroyed by the gale of 1875, was restored and 1,000 feet length of the Fort Point gabionnade constructed. This south dike was thus prolonged to the verge of Bolivar Channel as far north as it was intended to reach. As was anticipated, its construction contracted the water-way between Fort Point and Pelican Spit Shoals, and thus caused the scouring away of the inner bar to a depth of 20 feet at mean low-tide.

Simultaneously with resumption of work on the south pier the Bolivar Point jetty was commenced at its inshore end, and for a length of 513 feet was formed with a double row of piling. This piling, however, in spite of all efforts made to save it by ballast thrown in along its base, was undermined and washed away by the gale of the following September, 1877.

The gabionnade, which had also been commenced in prolongation of the pile structure, withstood the storm. Gabions 12 feet long, 6 feet wide 6 feet deep, with semi-circular ends, were placed lengthwise in a single row at first upon the sand bottom, afterwards upon reed mats about 3 inches thick, giving an apron 6 feet wider on either side than the ga

bionnade. This apron was ballasted by concrete blocks. The jetty as thus formed up to June 1, 1879, had been extended seaward to a distance of about 7,000 feet, and included the placing in position of 637 gabions.

That the system of construction adopted for the Galveston jetties and carried out up to that date had not proved satisfactory in its application to the Bolivar pier was evidenced by the recommittal of the subject for consideration and report June 3, 1879, Special Orders 63, Headquarters Corps of Engineers, to the same Board of officers (excepting only one member) as that originally ordered thereon. Three and a half years had elapsed since their last meeting, during which period the progress already detailed was made on the piers. From Major Howell, the member who had been in general charge of the work from its inception, it was ascertained that the gabions, wherever placed directly on the sand without intervention of mattresses, had already sunk from one-half to two-thirds of their height, below the bottom level; that they had not caused any permanent collection of drift sand on the north side as had been anticipated; but that, for the portion of the length laid which crossed the swash channel, the process had been one of undermining on the south side, the water having deepened from 9 to 12 feet. This undermining process let the gabions down so that they projected but a little above the sand bottom. It also appeared that of the 637 gabions placed, about one-sixth part had been broken up, leaving large gaps in the pier. Major Howell attributed their destruction in part to the fact that many of them had been kept on hand between one and two years before they were put into the water, and that, in consequence, the wood of which they were made being partially decayed had lost its strength; and farther, that many of the gabions thus destroyed were not entirely filled with sand, and did not, therefore, attain their full weight and stability.

The Board fully comprehended the difficulties of the position and the unfavorable circumstances attending the construction, and the magnitude of the enterprise—the building of 7 miles of piers into the Gulf of Mexico, in waters varying from 5 to 18 feet depth, mostly covered by breakers with every high wind from northeast around to southwest. It seemed to them that any methods of construction departing, with a view to economy, from the hitherto established modes would have been attended with delays, reverses, and losses. Yet the fact remained that one-sixth part of the pier had been destroyed, and though defects in construction might in part account for the magnitude of the loss, the Board saw in it the confirmation of their original opinion that the gabion would not prove strong enough to endure the continuous shock of waves and breakers, and that it would eventually be disrupted, lose its sand filling, and be scattered unless covered by sand drift. As no member of the Board, however, had seen the work in progress, as they were not satisfied that the gabion had been tried in the best manner on the Bolivar pier, they concluded not to condemn the system irrevocably without personal examination and without being sure that, profiting by the experience gained, the causes of the partial failure which had occurred on the Bolivar pier might not be met and remedied. As a large number of gabions were on hand it was thought advisable to strengthen them by additional braces, and to try a variety of methods of placing them before pronouncing finally upon their success or failure. It did not seem impossible that they might be so arranged as to cause the collection of drift-sand and thus protect themselves.

The Board, therefore, in conclusion, advised that Major Howell construct no more gabions, but strengthen those on hand and place them

in the pier according to the different methods suggested, causing close observations to be made with a view to determine the cause of the failure of those that might be destroyed and to gather such other experience as would enable them to judge of the system after the trial. They also suggested the trial of the Dutch system of jetty construction, of alternate layers of brush mattresses and stone, provided stone could be obtained from the Trinity or San Jacinto rivers above, or from any other source more cheaply than concrete could be made. If not, that concrete in blocks or in bags should be used.

The Board were desirous to ascertain the cost of this method as compared with others, also if the small stone or concrete blocks would so far maintain their position in the jetty under the shocks of the frequent storms of this coast, as to make the construction a success. (See Report of August 9, 1879.)

From information derived since the date of our last report through General Gillmore, who visited Galveston, in December, 1879, and from various reports made by the assistants on the work, it appears that from June 1 to December, 1879, 289 gabions were placed in the Bolivar pier, but that they were in no manner strengthened before being used. Ten of these gabions were set crosswise, twenty in two rows, side by side, twenty-eight in a detached row slightly oblique to the main line with which it was connected by a spur of ten gabions, and that of the whole number laid, sixteen had been destroyed.

Captain Davis's reports showed that from its commencement, April 14, 1877, to January 1, 1880, the Bolivar pier had been extended seaward from the beach 10,220 feet, 513 of which in shore had been a pile construction, and 9,707 feet a gabionnade. The latter was formed of 922 gabions placed, with the few exceptions above enumerated, lengthwise in a single row. About one-third of these gabions were placed directly upon the sand bottom, the other two-thirds upon thin mats, as already described.

Of these gabions, 98 have wholly disappeared, 17 have broken away from bottoms, 3 have lost their tops and part of their sides, 7 have lost their tops, 4 tops loosened when last examined.

Seventy-five of the above have been replaced. Examinations made from time to time to determine the positions of the gabions showed some lateral displacement, and incidentally a large amount of settling. It does not appear that the supple mats upon which the greater portion of the gabions rested prevented in any wise their sinking into the sand, as those set in place in the summer of 1879, by reports rendered soon after, had settled very rapidly and seemingly to their full depth below the bottom. It is apparent that the mats were neither wide enough nor solid enough to be of any avail. The accompanying sketches 1 and 2 show the lateral and vertical disturbances of the gabions in the Bolivar pier so far as examinations have determined. Captain Davis's letter of March 7, 1880 (Appendix A) gives some interesting data connected with the construction of the gabionnade, the examinations made thereof from time to time, the extent of the injuries it received, its subsidence and its probable condition. It also furnishes an account of the trial of mattresses sunk last winter in or near the inshore part of the Bolivar pier.

Though but 16 of the 242 gabions placed in the extension of the Bolivar pier between June 30 and December 1, 1879, had been damaged or destroyed at the date of their last examination, yet 10 of the last 38 laid in October and November had disappeared. These latter were placed in a greater depth of water and were exposed to greater wave action than those nearer the shore and to storms before much subsidence had

occurred. It appears from the testimony of Captain Davis that all of the above gabions, after the lapse of two or three months, had settled down below the original bottom level nearly to their own height (6 feet), and were subjected thereby to some lateral displacement and were much inclined lengthwise and sidewise. It is probable that in this process of settling those that had disappeared were strained and broken, while those remaining, having attained their final subsidence, were partially buried, and, thus protected from wave action, become immovable. It certainly does appear that if we exclude the great loss of July and August, 1878, and of those of October and November, 1879, the percentage of gabions destroyed has been very small. We cannot, however, infer from the foregoing that the gabion as constructed—a shell of wickerwork cemented on the inside and out, with a total thickness of about 6 inches and filled with sand—is strong enough to endure perpetual exposure to wave action in this locality, unless it acquires stability and protection either by sinking down partially into the sand or by being partly covered by sand drift. It has failed, however, as applied in the Bolivar jetty, to gather sand-drift and to constitute a pier. In fact, the gabionnade has essentially gone down below the original bottom. The matting used proved an insufficient base for the gabions and they have disappeared as loose stone would have done had they been used in their stead. It is doubtful if their projection above the bottom is sufficient to give any sensible contraction of water-way. What might have been the result had the gabions been placed upon an unyielding platform wide enough to have prevented the process of undermining, there are no facts to determine. Had they been placed, as at Fort Point, in two rows, with cross-walls and lateral spurs, they might possibly have gathered sand and thus formed a pier; but the structure would have lost the special merit claimed for it—simplicity and economy.

The effect of the works at Galveston has been to remove the inner and to narrow the outer bar, measured between the 18-foot bottom curves about 2,000 feet. This last result may have been entirely produced by the repairs of the city dike and its prolongation as a gabionnade nearly half a mile in a northeast direction. The contraction of the outlet resulting therefrom would concentrate the outflowing water, increase its velocity and its living force, and hold it together against dispersive forces to a greater distance from the shore line, and thus effect some scouring on the inner slope of the bar. If the Bolivar pier had any effect in narrowing the outer bar, such result must have been very small, as its progressive sections by rapid subsidence soon ceased to be any obstacle to prevent the dispersion of the outflowing current in that direction. The results produced, however, are quite sigificant, and seemingly promise from the submerged jetties, when completed, all the depth over the bar anticipated.

It is now proposed by Major Mansfield, who has recently relieved Major Howell of the charge of all the works of improvement on the Texas coast, to utilize the 340 gabions on hand to construct a part of the south jetty from *a* to *b*, a length of 4,080 feet (see accompanying map 1). The intention is to place them on mattresses 30 feet long, placed across the line so as to project 12 feet on either side of the row of gabions. The above recommendation seems to be made in the hope that this position, for special reasons, is favorable to the collection of drift-sand, and that in consequence the gabionnade will be covered and protected. Should, however, the waves and currents prove adverse to such collection, and the structure in that sense be a failure, it is claimed that the "mattresses and riprap can be utilized as a lower

course in constructing a stone jetty," and the loss incurred will be simply the cost of placing and filling the gabions.

In the winter of 1879–'80 (December, January, and February), an experiment was made at Galveston with mattresses, as shown in sketch 3. Commencing near the inshore end of the Bolivar pier, mattresses, formed of cane and brush, 1 foot thick, and mostly 18 feet wide and 30 feet long, were laid for nearly half a mile in length, partly in four rows side by side, but for the greater portion in two rows, the seaward end, however, consisting of a single row only. They were held in place by concrete blocks with an average weight to the square foot of surface of about 21 pounds. The cross-sections of sketch noticed in reference to the order in which the different sections were placed show some disturbance of the bottom level, with but slight accumulation of sand, and, as Captain Davis says in his report, "no tendency to envelop the mattresses with it." All the experiments that have been thus far tried on the line of the north jetty give no evidence that sand will accumulate around any obstruction to currents and waves that may be put upon the sea bottom in that locality.

The trial made last winter of the mattress 30 feet wide and 60 feet long on the north pier line, does not indicate that it will prove a suitable base for the gabion to stand upon, nor a sufficient foundation either for a stone enrockment or for a mixed stone and fascine jetty. If put down in the south jetty from *a* to *b*, in from 8 to 11 feet of water, it may be undermined and drop the gabions resting upon it down into a trench, as they settled in the north pier on the 18-foot mattresses. In truth such result would naturally be looked for unless the wave and current action at this locality prove exceptional. All the experience thus far gained on the Galveston jetties shows that the base assumed for them has been too narrow and unsubstantial. The first success at Fort Point seems to have been due to the placing of one row behind another, with frequent walls uniting them and spur-dikes to prevent the undermining process. Besides, at that position, there was an undoubted tendency to the collection of sand-drift coming in from the southwest.

Experience in building the north pier of the harbor at the mouth of the North Sea Canal with large stones and concrete blocks, developed the necessity for a wide base on which they should rest. The width of enrockment finally adopted for that purpose was 100 feet. The base of the Maas jetty, Holland, was made 50 meters wide. The timber, brush, and stone apron used as a basis for the dike closing New Inlet, between Federal Point and Zeke's Island, near the mouth of Cape Fear River, North Carolina, varied from 40 to 70 feet in width. There was a scouring effect produced in advance during the laying of this apron, which dropped it down about 3 feet below the original bottom. There was also scouring on either side, which required stone to be thrown in, widening the base largely as the dike was raised. The scouring was evidently due to the overfall and not to parallel currents. It should be remarked in this connection that the current through New Inlet was a rapid one. The Charleston submerged jetty is an apron similar to that used at New Inlet, North Carolina, for the base of the closing dike, and as far as it has been put down has varied in width, according to depth of soundings, from 43 to 113 feet.

CONCLUSION.

From the foregoing it would appear that a substantial base from 50 to 100 feet wide, varying with depth of soundings and characteristics

of the position, will be required for the Galveston submerged jetties whatever may be the method of construction determined upon.

On the north pier 7,000 linear feet were put down apparently on the assumption that the success of the system had been established at Fort Point, and hence with insufficient examinations to determine whether or not the structure was fulfilling the end designed. This error should not be repeated on the south pier by laying a section 4,080 feet long on a mattress but 30 feet wide, as proposed. If such experiment is to be made at all (and we have little faith in the sufficiency of the 30-foot mattress, or expectancy that the gabion will be covered with drift sand), it would be judicious to limit it to a length of 200 feet, and to test it by one season's exposure. We are of opinion, however, that it would be better without more delay to adopt a wider and more substantial base for the trial—one, for example, shown on attached sketch A.

The estimate of the Board for this base is but $13.23 per linear foot. The amount of stone or concrete allowed for may seem too small, but the weight of the gabion will be sufficient to hold the raft down. Even should more blocks be needed, the estimate will scarcely exceed $20 per running foot. It has been assumed that logs and brush or cane are to be readily and cheaply obtained in the vicinity.

We prefer stone to concrete as ballast for the raft, and if it can be obtained in the vicinity it will be the less costly of the two materials. It can probably be procured from northern ports for $5 per cubic yard. Small stone will pack well thrown upon the brush of the raft, and if filled with sand and covered with sea-shells before being displaced by violent storms, will make a solid mass. Even should concrete blocks be laid upon the mattresses as represented on the drawing, it would be well to fill in between with small stones.

Concrete can probably be made of Rosendale or Saylor's Portland cement at $6 per cubic yard, as will appear from the following estimate:

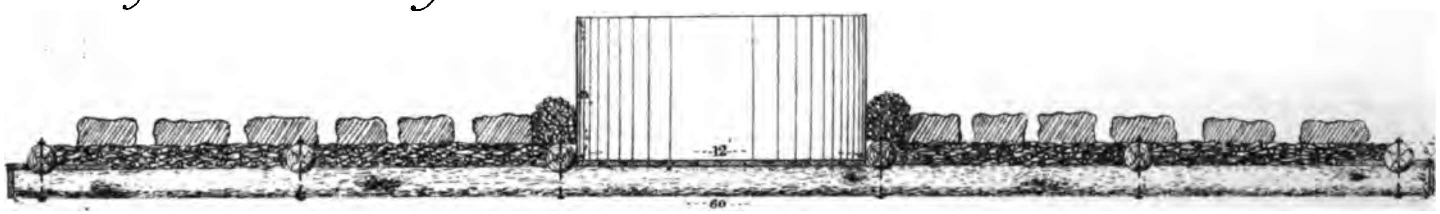
300 pounds Saylor's cement at .8 cent	$2 40
8 cubic feet river sand (dense), at 9 cents	72
24 cubic feet river gravel (dense), at 9 cents	2 16
Making, including ramming and molding	72
Cost for one cubic yard	6 00

The method of construction shown in sketch A may be varied by placing the gabion lengthwise instead of crosswise on the grillage, and by giving the mattress on either side of it a greater thickness and covering it entirely with stone with a view to greater solidity and to the collection of drift-sand. This project is proposed simply to take the place of that submitted by the local engineer at Galveston for utilizing the gabions on hand, and it is understood that no more gabions are to be constructed. Its merit consists in the solidity of the raft itself, so that should the gabions break up, additional stone thrown in would convert the structure into a serviceable jetty.

Sketch B, annexed, shows a solidly made mattress with 60 feet base and with an average thickness of about 3 feet. It is covered with concrete blocks, but stone would be better as more dense and less liable to be removed by the waves. The structure will require to be strongly bound together to resist breaking while being towed to its position. The thickness of the mattress itself, as well as of the stone covering, should vary with the depth of water in which it is to be sunk, and the exposure of the position. It is possible that the annexed estimate for this structure is too small, and that the difficulties and delays of placing it in the open Gulf will much increase its cost. It would scarcely be safe, therefore, to estimate it at less than $40 per linear foot.

Sketch A.

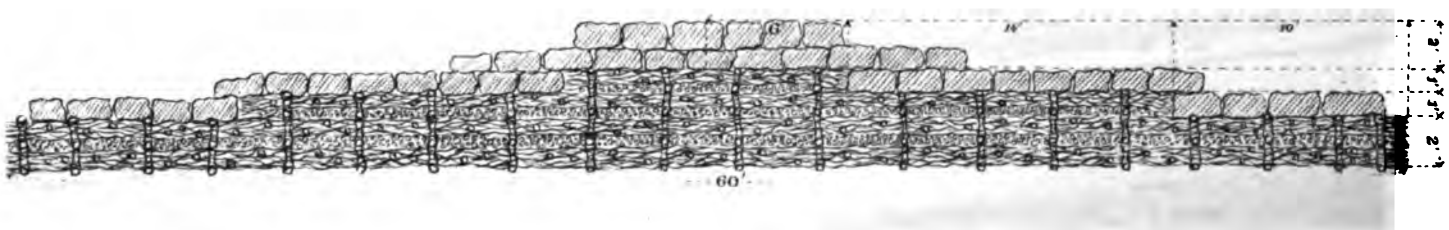
Cross Section of proposed Galveston Jetty showing grillage of logs; covered with mattresses and concrete blocks arranged to receive the Gabions now on hand, placed crosswise. The Gabions may be placed lengthwise, and stone may be used instead of concrete



Sketch B.

Cross section of proposed Galveston Jetty, showing mattresses covered with Concrete blocks.

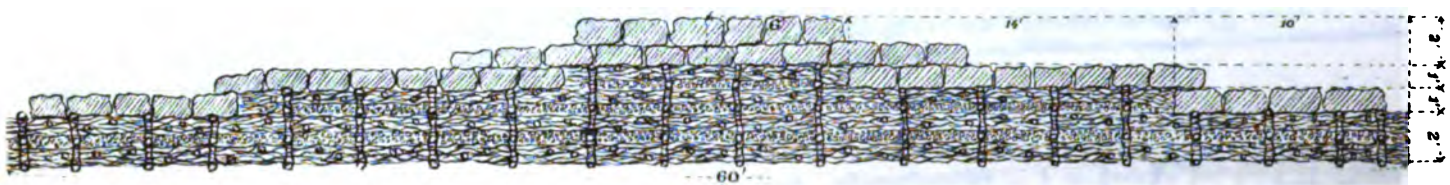
Stone may be used instead of concrete.



Sketch B.

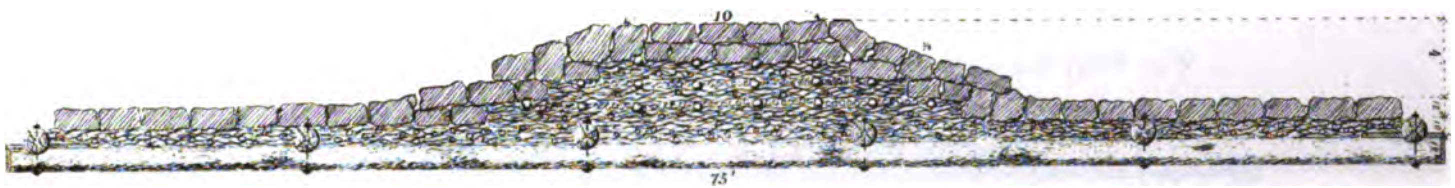
Cross section of proposed Galveston Jetty, showing mattresses covered with Concrete blocks.

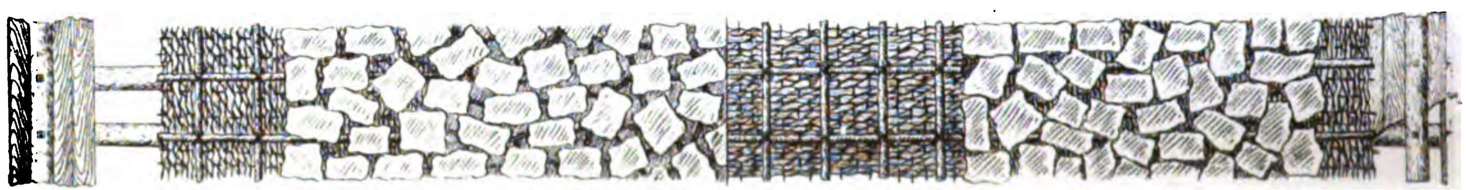
Stone may be used instead of concrete.



Sketch C.

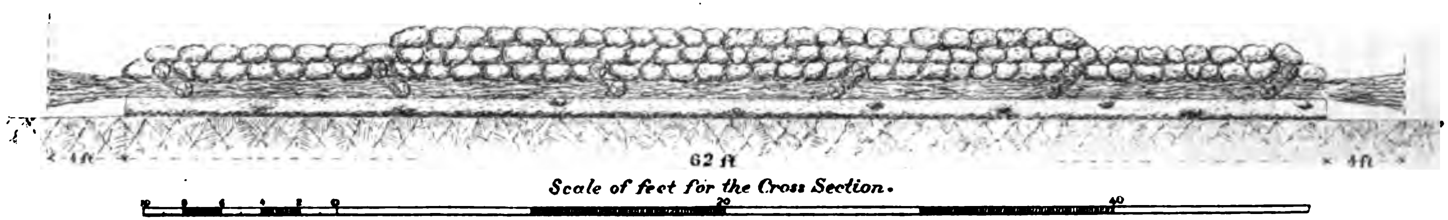
Cross Section of proposed Galveston Jetty, showing grillage of logs covered with mattresses and concrete blocks.
Stone may be used instead of concrete





Sketch D.

Cross Section of Apron for Charleston Jetties, as laid in 1878-79.



We further submit for trial the methods of construction represented by sketches C and D, annexed. The first is a grillage of logs, the lower set placed 3 feet distant from center to center and crosswise to direction of jetty, and firmly bolted to the longitudinal binders, which are few in number. Thin but compact mattresses fill the spaces between the binding logs, while the central portion or heart of the construction is formed of a solid mattress varying from 1 to 3 feet in thickness. Though blocks of concrete covering the mattresses represent the weight required to hold the mass in position, it is understood that stone will be preferably used if readily procurable. The dimensions given will probably suffice for depths up to 11 feet, unless there is much settling. In shoal water the thickness of central mattresses and width of base may be reduced.

Sketch D represents cross-section of the apron used in 1878 and 1879 in the foundation for the submerged jetties on Charleston bar, South Carolina, and which thus far has proved successful. For full description of this construction see Annual Report of the Chief of Engineers for 1879, Appendix I.

As small stones upon structures exposed to the action of breakers will be more or less displaced during storms, we must anticipate some damages to result from the application of either of the above methods to the construction of the Galveston jetties. Either of them, however, will probably prove a success, provided the brush collects sand and the stones become bound together by molluscous concretions, which usually grow rapidly in warm climates. Experience in Charleston Harbor and on the shores of Holland, especially at the mouth of the Maas, bears testimony to the rapid growth of these mollusca upon loose stones immersed in the sea near the outlets of fresh-water tributaries, and to their effective use in cementing them, as it were, into one mass. Though we anticipate with no degree of certainty the same favorable results at Galveston as at Charleston, yet it seems probable that similar shell deposits will occur and that the brush and stone will collect sand in process of time. Unaided by such favorable action, the solidification of the jetties will be difficult and costly.

The Board are disposed to favor the grillage or raft system as giving a stiffer base than the mattress unsupported by logs.

We recommend, however, the trial of the several methods proposed, by constructing, during the present summer, sections of the Galveston jetties in general accordance with annexed sketches, using as a covering about 2 feet thickness of stone instead of concrete, if stone can be procured. By the exposure of the succeeding autumn and winter, the sections built will be tested. When a satisfactory method of construction has been determined we are of the opinion that the Galveston jetties should be built by contract, rather than by the system now followed. In the mean time there should be as little expenditure for plant as possible.

From the direction taken by the Cylinder Channel it would appear that the direction of the north jetty for a distance of 2 miles from the shore need not be changed. The south jetty should incline more to the north, taking direction indicated by line AB, so as to contract the opening between the two at their outer ends. Neither, however, should be carried more than 2 miles seaward until the other has progressed nearly in equal ratio, and the effects produced by their prolongation, noted from time to time, will determine the final directions the outer portions should take.

It has always been assumed that the Galveston jetties are to be submerged, but to what depth can only be determined by results produced

during the progress of their construction. Should an average height of 5 feet above the sand bottom prove sufficient to subserve the purpose for which they were designed, it seems probable that they can be constructed by either of the methods proposed (stone being furnished from the vicinity) for $40 per linear foot.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers and Bvt. Maj. Gen.
JOHN NEWTON,
Colonel of Engineers and Bvt. Maj. Gen.
Q. A. GILLMORE,
Lieutenant-Colonel of Engineers and Bvt. Maj. Gen.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

ESTIMATE FOR A SECTION 30 FEET LONG.

11	grillage logs, each 60 feet long, at 6 cents	$39 60
6	binder logs, each 30 feet long, at 6 cents	10 80
350	pounds of 1-inch round bolts and nuts, at 8 cents	28 00
5	mattresses between binders, each 10 inches thick = 28 cubic yards, at $1.50	42 00
2	fascines, 7 cubic yards, at $1.50	10 50
1,800	feet, board measure, 3-inch plank, at $18 per M	32 40
50	pounds of spikes, at 5 cents	2 50
22	cubic yards of concrete or stone, at $6	132 00
		297 80
Contingencies, at 33⅓ per cent		99 26
Total for 30 linear feet		397 06
Cost per linear foot		13 23

Every 5 feet of increase or decrease of width will add to or subtract from above cost of linear foot about $1.

ESTIMATE FOR A SECTION 30 FEET LONG.

191	cubic yards of mattress, at $1.50	$286 50
80	cubic yards of concrete or stone, net measurement, at $6	480 00
		766 50
Contingencies, at 33⅓ per cent		255 50
Total for 30 linear feet		1,022 00
Cost per linear foot		34 06

Every 5 feet of increase or decrease of width will add to or subtract from above cost of linear foot about $2.

The mattresses should be made compact by drawing the surfaces together by suitable ties.

ESTIMATE FOR A SECTION 30 FEET LONG.

11	grillage logs, each 75 feet long, at 6 cents	$49 50
6	binder logs, each 30 feet long, at 6 cents	10 80
350	pounds of 1-inch round bolts and nuts, at 8 cents	28 00
5	mattresses between binder logs, each 10 inches thick = 61 cubic yards, at $1.50	91 50
1	mattress, 1 foot to 3 feet thick = 62 cubic yards, at $1.50	93 00
720	feet, board measure, 3-inch plank, at $18 per M	12 96
22	pounds of spikes, at 5 cents	1 00
100	cubic yards of concrete or stone, neat measurement, at $6	600 00
		886 76
Contingencies, at 33⅓ per cent		295 58
Total for 30 linear feet		1,182 34
Cost per linear foot		39 41

Every 5 feet of increase or decrease of width will add to or subtract from above cost of linear foot about $2.

The mattresses should be made compact by drawing their surfaces together by suitable ties.

REPORT OF MAJOR S. M. MANSFIELD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Texas, March 25, 1880.

GENERAL: I have the honor to submit the accompanying report of Assistant Ripley, it being a suggestion of his for a disposition of the gabions on hand at Bolivar Point.

It is very necessary to get rid of these gabions, if only for the room they occupy, and my desire has been to utilize them to the best possible advantage. Mr. Ripley's project meets my approval, and I submit the report without comment, beyond the suggestion that the mattresses be kept well in advance of the gabions during construction, to counteract any tendency to scour in advance of the work.

The placing of these gabions will absorb about the balance of available funds, and will build 4,080 feet of the jetty, and will require the whole of the coming season for its execution.

The probable success or failure of this gabionnade will be determined soon after the work is begun. The conditions seem to favor success.

The plan of the Board of Engineers was to utilize the gabions on hand. It may be they intended to confine their use to the Bolivar jetty. I therefore submit the matter for your consideration and approval.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Col. U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

BOLIVAR POINT, *March* 22, 1880.

COLONEL: I would respectfully suggest a disposition of the gabions which we have on hand.

We have 317 gabions entirely completed, and 23 partially so, making a total of 340. These will construct 4,080 feet of gabionnade. I send herewith a tracing upon which is shown, in red, the proposed line of the south jetty. The blue line, extending from the 6-foot curve out 4,080 feet, shows the position where I would suggest the use of the gabions. If they be placed on mattresses, say 30 feet long, placed across the line, extending, as they would, 12 feet on either side of the gabions and well riprapped on either side to prevent lateral displacement of the gabions, I think they would settle but little, and would resist the action of the waves until they became covered with sand. We are encouraged in the belief that they would become immediately covered, from the fact that before the storm of 1875 there was but 5¼ feet of water where there is now 15 feet, and where there is the deepest water on this line, there was but 6 feet in 1872. There seems to be a tendency to a reformation of a shoal at this point, as is shown by the shoal-water a short distance to the southward. This tendency is resisted by the ebb-tide concentrated at this point, and which, being cut off by a line of gabions, will allow the sand to form a bank on the sea-side and finally cover the whole line, as was the case at the Fort Point gabionnade. There would be an average depth of 4 feet on tops of the gabions and about the same depth on the shoal extending to the pile breakwater, which would leave an opening of 8,800 feet length and 4 feet depth for the admission of the flood-tide at the shore end of the jetty—a condition, it seems to me, very much to be desired. If it be feared that a channel would be cut through between the inner end of this and the Fort Point gabionnade, a single tier of mattresses well covered with stone would prevent it; but I think there

is no possible danger of it, for the water from Galveston channel pushes out against that of Bolivar channel and prevents its spreading at this point. Even were there considerable doubt of its success. I think it well worth the experiment, from the fact that we have the gabions on hand and the cost of placing them is so small compared with the cost of a stone jetty that in case of success the saving would be enormous.

For example, the cost of placing 95 gabions in October and November, 1877, was $16 per gabion (estimated at the time), or $1.33 per running foot. The cost of mattress 30 feet wide is $1.83 per running foot. The amount of concrete for riprap, say 2 feet high at gabion, and sloping down to half a foot at a distance of 12 feet, would be 30 cubic feet, and its cost, at 25 cents per cubic foot, would be $7.50 per running foot.

The placing of the mattresses and riprap would cost, say, $1 per running foot. The total cost of gabionnade would therefore be—

Placing gabions	$1 33	
Mattresses	1 83	
Placing mattresses and riprap	1 00	
Riprap	7 50	
		$11 66
Contingencies superintendence, &c., 30 per cent		3 50
Total cost per running foot		15 16

And 4,080 feet would cost $61,852.80.

It must be remembered, however, in case of failure, that the only loss will be the placing of gabions, for the mattresses and riprap can be utilized as a lower course in constructing stone jetty. The loss will, therefore, be $1.33 per running foot, and the total loss will be less than $5,500.

The same height of stone jetty, roughly estimated, would cost $80 per running foot. Should the gabionnade, therefore, prove a success, which the conditions seem to favor, there would be a saving of $65 per running foot, or a total saving of $265,200.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Bvt. Lieut. Col. S. M. MANSFIELD,
Major of Engineers, U. S. A.

APPENDIX A.

REPORT OF CAPTAIN CHARLES E. L. B. DAVIS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., March 7, 1880.

SIR: I have the honor to submit the following replies to the questions propounded by General Tower, president of the Board of Engineers on improvement of entrance to Galveston Harbor, in his letter addressed to you dated February 23, 1880, which letter you handed to me with the request to state my views.

I transmit with this letter two tracings, one showing a plan and elevation of the Bolivar gabionnade entire, as it existed at times of last examinations; there is also shown a plan of the sheet-piling, extending from the shore to the inner end of the gabionnade, which was destroyed by the storm of September, 1877; the legend and notes upon this tracing will explain it and help to make my answers to General Tower's questions more readily understood.

The second tracing shows the positions of the mattresses put down since the construction of the Bolivar gabionnade was discontinued.

In order to be as concise as possible, I will take up the questions *seriatim* and answer them.

1st. "How many gabions have been put down since the Board's report was made last summer?"

The total number of gabions put down since June 30, 1879, is 242. An examination of the tracing will show but 237, as 5 of those put down in November, at what was then the extreme outer end of the gabionnade, had disappeared before their first examination, and hence are not shown upon the tracing.

2d. "Were those gabions (known to be on hand) strengthened in any way before they were put in place, or were used without being strengthened? If strengthened, how was it effected?"

Gabions on hand at the time of the Board's report were used without being strengthened. The weakness of the gabion arises from the fact that it is an exceed-

ingly elastic wicker-work covered with an inelastic cement coating, which coating when the gabion is subjected to any strain, is certain to crack and flake off. To strengthen a well-seasoned completed gabion could only be done in two ways, either to put in additional bolts or to put on an extra coating of cement. The first method would endanger cracking the cement on attempting to tighten the bolts, and the second would have presented the difficulty of making the new cement coating adhere to the old.

3d. "Describe mat upon which they were placed—length, breadth, thickness, material. Strength estimated roughly to determine whether they would break or bear the gabions placed upon them."

The mats upon which the gabions were placed were 12 by 18 feet, made of 3-inch fascines placed side by side and tied together with houseline at intervals of about 3 feet, in the following manner:

Commencing in the center of a piece, the line is passed over and under the fascine, the two ends crossing on the other side and tied with a flat knot. The two ends are then carried over and under the next fascine, and so on across the mat.

Eight battens, 1 inch by 6 inches, are then placed lengthwise of the mat, four on either side opposite each other, and fastened together with galvanized-iron wire passing between the fascines and around the battens at intervals of about 2 feet. The fascine is made of river cane as an outside casing and filled in the center with the branches trimmed from the same cane and tied together with marline, passing twice around at intervals of about 9 inches. Twelve concrete blocks are placed upon the mat, 6 at each end, to keep it in position. A concrete block is 6 inches by 18 inches by 30 inches and weighs about 230 pounds. The blocks are wired fast to the mat with galvanized-iron wire. The mat is placed the long way across the line of the gabionade, and the gabion being placed the long way with line, lies across the mat between the concrete blocks. The mats thus constructed are flexible and conform to the shape of the bottom, and as far as is known they have sustained the gabion without breaking. The ends of mats upon which the blocks are placed have in every case as far as is known settled as much or more than the center upon which the gabion is placed. The only way in which settlement has occurred is undoubtedly by the sand being washed from underneath the mat.

4th. "How were gabions placed—crosswise or lengthwise, in one or two tiers, close or separated?"

This question is well answered by the tracing, with this exception, that where gabions are much separated it is due to a movement after being put down. It was attempted to place them close together, and generally they were but little separated when first put down.

5th. "How many have since been broken to pieces or ruined by storms?"

Since the 1st of July, 1879, thirteen gabions have disappeared altogether and two have been broken, leaving the bottoms in position upon the mats, and one has the top gone, making a total of sixteen broken or disappeared.

Extracts from reports made from time to time will furnish the specific information called for.

[From report of September 20, 1879, concerning gabions placed in July.]

* * * "There is one gabion short of the number put down, and one gabion, No. 702, out of line. This gabion was put down close to No. 701, and was left, at the close of a day's work, partially filled with sand. Two days later it was found in its present position. It is altogether probable that the one that is missing disappeared in a similar manner, but was carried so far from the line as not to be discovered. * * * Nos. 606 to 612, inclusive, were examined July 19, eighteen days after they were put down. Nos. 613 to 627, inclusive, were examined July 21, from ten to twenty days after they were put down. Nos. 628 to 669, inclusive, were examined July 22, from four to eleven days after they were put down. Nos. 670 to 686, inclusive, were examined July 29, from seven to eleven days after they were put down. Nos. 687 to 702, inclusive, were examined July 30, from two to eight days after they were put down. Nos. 703 to 709, inclusive, were examined August 2, from two to five days after they were put down.

"On account of some doubtful locations and a discrepancy between the number of gabions examined and the number put down as shown by Captain Elwell's memorandum, a re-examination was made from Nos. 709 to 633, working from the outer end towards shore. Nos. 709 to 705, inclusive, were re-examined September 3, thirty-two days after their first examination.

"Nos. 704 to 665, inclusive, were re-examined September 4, thirty-three to forty-four days after their first examination. Nos. 664 to 633, inclusive, were re-examined September 16, fifty-six days after their first examination.

"The settlement which took place from time of first examination to time of re-

examination, and depth of water on top at time of re-examination is shown in the following table:

Gabions.	Time.	Average settlement.	Average depth.
Numbers.	*Days.*	*Feet.*	*Feet.*
633 to 664	56	2.39	5.61
665 to 669	44	3.28	6.20
670 to 686	37	2.28	6.63
687 to 702	36	2.19	6.26
703 to 704	33	1.20	5.15
705 to 709	32	2.94	5.88

"The least settlement shown is 1 foot (No. 694) and the greatest is 4.8 feet (No. 665).

"It must be remembered that the settlement thus shown is not the total settlement since the gabions were put down.

"To get the total settlement there must be added the settlement prior to the first examination. This is not known, but since the gabions settle most rapidly for the first few days after being put down, it is probable that the settlement prior to the first examination exceeds the amount shown in the table. The fourth column of the table, which shows the depth of the water on the top of the gabions, gives a good idea of their total settlement when it is remembered that the tops of many of them were at the surface of the water when first put down.

"All the gabions seem to be in good condition except No. 646, which has lost its top, and the sand filling is gone."

[From report of November 17, 1879, concerning gabions placed in August and September.]

* * * * * * *

"Two gabions, Nos. 750 and 751, had been carried away, leaving the mats and blocks in position. Two other small gaps have been caused by the shifting of the gabions as shown at Nos. 720 and 732.

"In the former case four gabions, Nos. 716 to 719, have shifted from a straight continuous row to the position in which they are shown on the tracing. These movements are evidences of the shocks which the gabions are called upon to resist, now that the outer end has passed the last shoal and must henceforward receive the full force of the sea.

"During September, construction was confined to a wing and return line.

* * * * * * *

"In the partial inclosure thus formed, we should expect a rapid accumulation of sand, but soundings taken on the 21st of October show that up to that time no material accumulation had occurred."

[From report of January 6, 1880.]

* * * * * * *

"During the month of October there were placed in the gabionnade 30 gabions.

* * * * * * *

"Of these 30 gabions, 5 (Nos. 781, 784, 787, 788, and 789), have disappeared entirely, and others, notably No. 763, show evidence of considerable displacement.

"During the month of November there were put down 8 gabions. Four of these were put down on the 3d. Two of these, the outer ones, had disappeared on the 19th, and were replaced, and two additional ones were put down. December 16, when the examination was made, only three remained of those put down in November.

* * * * * * *

"It is worthy of remark that at the outer end where the gabions disappeared the mats remained as they were placed."

6th. "Has it been a success as a system, or a failure?"

In my opinion it has been a failure.

7th. "Has it caused the formation of drift sand against it or not?"

No formation of drift sand against the gabionnade has occurred. There have been accumulations of sand on the north side of the line, and they have disappeared or shifted from place to place, and reappeared a number of times, but nothing approaching a permanent sand formation can be said to have resulted from the gabionnade.

7th. "Second. As to the old gabionnade built before July last, what is its present condition? Has it deteriorated much during the past 7 or 8 months?"

No recent examination of the older portion of the gabionnade has been made.

In July, 1879, that portion constructed in May and June was examined, and the condition at that time is shown by the following:

[Extract from report of August 1, 1879.]

* * * * * * *

"In their settlement many of the gabions have worked out of position, and one (No. 579) has gone away. From No. 586 to No. 604 most of the gabions are more or less out of line. This is partially due to settlement and partially due to an imperfect ranging of the guide piles."

Its present condition is not known, but there is no evidence that it has greatly deteriorated in the past seven or eight months.

8th. "How many gabions have been broken to pieces during that period?"

There is no positive information as to the number of gabions broken to pieces during that period, but from the absence of débris upon the beach it is believed that the destruction has been very slight.

9th. "Have the gabions settled farther down into the sand?"

There is no information with regard to their settlement lately. It is probable that the oldest portion (that constructed in 1877) has ceased to settle, the tops of the gabions having long since nearly, if not quite, reached a depth on a level with the general surface of the bottom.

10th. "Does it in any way fulfill its purpose, or is it mostly a waste of means?"

In my opinion it is mostly a waste of means.

11th. * * * "I desire to learn if mattresses of brush loaded with stone, as recommended by the Board of last summer, have been tried. If so, how were they made, and what has been their success?"

Mattresses of brush and cane have been placed in a single tier, as shown in the accompanying tracing, and loaded with concrete blocks (100 blocks to each mattress), as no stone could be obtained.

The concrete blocks are the same as those used in weighting the mats placed under the gabions. Mattresses have been principally made 18 feet by 60 feet, and about one foot thick over all. The cane or brush is laid one layer lengthwise, another crosswise, and another lengthwise, and all held in place by frames of wood above and below, fastened together with iron bolts, wooden pins, and galvanized-iron wire. A few mattresses, 18 feet by 30 feet, made in a similar manner, have been used. The success of the mattresses is shown by the cross-sections.

Let us consider cross section No. 1.

Mattress No. 1 was placed December 4, No. 2 was placed December 6, No. 4 December 15, and No. 11 December 16. Now, assuming that the bottom was level when No. 1 was placed, which was most likely the case, there was a slight accumulation before No. 2 was placed, and a slight scour before No. 4 was placed, and a still greater accumulation before No. 11 was placed. Cross-section A A shows a slight accumulation on both sides of the mattresses. Cross-sections Nos. 10, 13, and 14 each show an accumulation from time of placing, respectively, No. 40 and No. 42, No. 49, and No. 50, and No. 51, and No. 54. Cross-section No. 29, however, shows a scour from time of placing No. 81 and No. 89. There seems, therefore, little tendency to accumulate sand, and no tendency thus far to envelope the mattresses with it.

The placing of mattresses was commenced on the line of the gabionnade, but it was thought advisable to make an off-set, and thus avoid the deep trench and irregular bottom caused by the gabions.

12th. "Are there any palmetto trees, scrub oak, or any timber growth at or near Galveston? Any brush for mattresses?"

There is no palmetto in Texas. The river banks are covered with timber, pine, pecan, ash, willow, &c., though of a rather poor quality for mattress making.

All of the rivers in Texas are extremely tortuous, and navigable only a short time in the whole year, making water transportation very uncertain, and consequently expensive.

It is thought that river cane, if furnished in large quantities, and not selected according to sample for matting gabions, could be obtained cheap enough for mattresses, and would certainly be a good material for that purpose.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Captain of Engineers.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

N 4.

IMPROVEMENT OF SHIP CHANNEL IN GALVESTON BAY, TEXAS.

Estimates, together with report of "Survey at Buffalo Bayou for a channel of navigation through Buffalo Bayou and Galveston Bay to Bolivar Channel, near the outer bar in the Gulf of Mexico," were rendered April 4, 1871, for improvement of channel designed to accommodate a large portion of the commerce of the district.

The several acts of Congress have given to this work—

June 10, 1872, $10,000, and June 23, 1874, $10,000=$20,000; by which a channel was dredged through Red Fish Bar, 1,500 feet long, 70 feet wide, and over 7 feet in depth.

March 3, 1875, $35,200; by which a channel was made (between Bolivar Channel and mouth of San Jacinto River, and through Red Fish Bar) 6,100 feet in length, 14½ feet in depth, connecting depths in channel of 9 feet, and 8½ feet in the upper and lower bays, and, with the private work of improvement at Morgan's Point, permitting the passage of vessels of 9-foot draught to within a short distance of Houston.

August 14, 1876, and June 18, 1878, a total of $147,000; made applicable to that portion of channel between Red Fish Bar and Bolivar Channel; contract entered into with George C. Fobes & Co. December 3, 1878, to dredge channel 12 feet deep, 100 feet wide at bottom through lower bay, from head of Bolivar Channel to Red Fish Bar.

March 3, 1879, $80,000; "This amount made applicable on a direct line between the cut through Morgan's Point, subject to conditions that have not yet been placed in the form of legal documents required by the United States before application of the money appropriated." (Vide Report of Chief of Engineers, 1879, page 918.)

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1880.

REPORT OF CAPTAIN C. E. L. B. DAVIS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 1, 1880.

SIR: I have the honor to submit the following report of operations for improving the ship channel in Galveston Bay, Texas, from July 1, 1879, to February 25, 1880, the date of your arrival at Galveston, Tex.

The contract entered into with Geo. C. Fobes & Co., of Baltimore, Md., called for a channel 100 feet wide and 12 feet deep through lower Galveston Bay from 12 feet of water in Bolivar Channel to the cut through Red Fish Bar, a distance of about 10 miles.

As the dredgeboat could make a cut 40 feet wide without change of position it was decided to make three cuts successively the entire length of the channel, two of 40 feet, and one of 20 feet in width.

On July 1, 1879, the lower 3 miles of the first cut had been completed. From that time up to the date of your arrival work on the cuts was continued. The first cut was completed October 6, 1879, the second cut February 7, 1880.

During the time specified above the amount of material dredged was as follows:

	Cubic yards.
July, 1879	77,043.29
August, 1879	70,290.25
September, 1879	86,619.39
October, 1879	72,853.21
November, 1879	60,111.03
December, 1879	52,411.69
January, 1880	50,623.92
February, 1880	40,425.98
Total	510,378.76

The dumping ground for the lower 8 miles of the channel was to the eastward about three-fourths of a mile distant from the cut, and was marked out by a line of piles driven a mile apart and parallel to the cut. The dumping scows by keeping abreast of the dredge dumped the material in a continuous ridge, as it was thought this would be less of an obstruction to light-draught sailing vessels than if dumped in spots.

For the upper 2 miles of the ship channel, the dumping grounds were changed to the westward of the cut to avoid crossing a schooner channel at that point.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Captain of Engineers.

Maj. S. M. MANSFIELD,
Corps of Engineers, U. S. A.

During March, April, and May dredging was continued, the work being done satisfactorily, so that by the close of May the contractors, having delivered to the United States a channel in accordance with the terms of their contract, received final payment, and contract with them was then closed.

The material excavated and removed from channel under this contract amounted in the aggregate to 703,646.63 cubic yards, the entire work being done by one dredgeboat (the Charles Fobes), carrying a dipper of 4.22 cubic yards capacity, equal to discharging in scows alongside 200 cubic yards per hour.

Two dump-scows, with a total capacity of 438,172 cubic yards, and one tugboat comprised the rest of the plant, with the addition of a schooner of small tonnage as tender to the dredging fleet.

PROPOSED OPERATIONS FOR YEAR 1880–'81.

Available funds amount to—

Appropriation of March 3, 1879	$80,000
Appropriation of June 14, 1880	50,000
	130,000
Balance of appropriation of 1878	25,000
Total	155,000

This amount may be expended in improving the line from the cut in Red Fish Bar to the cut in Morgan's Point, and in continuing improvement in cut in the lower bay. To be done by contract, after advertising for proposals in the usual manner.

Original estimate (for channel 100 feet wide and 12 feet deep), 1877	$446,326 42
Appropriated (1872 to 1880)	302,000 00
Unappropriated balance of the original estimate (1877)	144,326 42

Which sum can be profitably expended in the fiscal year ending June 30, 1882, in continuing improvement as originally estimated for.

As heretofore reported, the work cannot be considered as one of a permanent character.

This work is in the collection district of Galveston.

For commercial statistics, see report of improvement of Galveston Harbor and entrance.

This work is designed to accommodate a large portion of the commerce of the district.

The light-houses on or near the line of the work are near Clopper's Bar,* at the mouth of the San Jacinto River, in Red Fish Bar, and at Bolivar Point.

* To be discontinued April 1, 1880.

Money statement.

July 1, 1879, amount available	$212,868 33	
Amount appropriated by act approved June 14, 1880	50,000 00	
		$262,868 33
July 1, 1880, amount expended during fiscal year		107,554 72
July 1, 1880, amount available		155,313 61
Amount (estimated) required for completion of existing project		144,326 42
Amount that can be profitably expended in fiscal year ending June 30, 1882.		144,326 42

N 5.

IMPROVEMENT OF TRINITY RIVER, TEXAS.

Plan and estimate for improvement was submitted April 29, 1871, based upon survey of the mouth of this river.

Recommendation and estimate for improvement, based upon survey of the "Trinity River from its mouth to Magnolia, Tex.," was rendered in 1873.

The appropriations of 1878-'79 have been made applicable to dredging of a channel 5 feet deep at mean low-tide, with a width of 100 feet across the bar at the mouth of the river, or so much thereof as the appropriation will permit.

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1880.

Work of dredging (contract of June 10, 1879, with Mr. Seth N. Kimball, of Mobile, Ala.) commenced June 1, 1880; and at the close of the fiscal year the number of cubic yards of material dredged averaged 22,000, the material being cast over and deposited upon the banks, cutting a channel 3,500 feet long by 65 feet wide and 5 feet deep throughout its length.

The weather, together with other difficulties arising, hindered the work so much that the contractor failed to complete the work here, as he intended, by the end of June.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1881.

Continuation of contract work—dredging bar—to the limit of funds available for the purpose. The expectations are that this contract with Mr. Kimball (the one mentioned as of date June 10, and a later one in continuation thereof, dated November 14, 1879) will be satisfactorily closed prior to the 1st of August, 1880.

Attention is here invited to the report "of the result of a resurvey of Trinity River, Texas, from its mouth to the bridge of the Great Northern Railroad, made in accordance with the provisions of the river and harbor act of March 3, 1879." (Ex. Doc., No. 135, Forty-sixth Congress, second session, copy herewith.)

THE ORIGINAL ESTIMATE (1871-'73).

1. *Work at mouth, dredging, and pile breakwater	$40,000
2. Removing snags, &c., between mouth of the river and Liberty	6,000
Total	46,000

* Estimate for dredging (1873) $16,581.40.

The amount appropriated by act of June 14, 1880, $4,000, may be applied to dredging a navigable cut through the bar 4½ miles below Liberty, which may cost $2,000; the balance of the appropriation may be reserved for such work of improvement as may hereafter be considered most judicious.

There is no basis for estimates as to the length of time the cuts made through the bar at the mouth and the bar near Liberty will remain open for navigation, or as to cost of maintaining the river from its mouth to Liberty in a navigable condition.

Original estimate (1871–'73)	$46,000
Appropriated (1878–'80)	16,500
Unappropriated balance	29,500

Twenty-nine thousand five hundred dollars can be profitably expended in continuing improvements—dredging channel, removing snags, &c., and constructing requisite protection work in the next fiscal year.

The work is located in the collection district of Galveston. Nearest light-house, Red Fish Bar, Galveston Harbor.

STATISTICS.

Considerable lumber is brought down the river, but I have not been able to obtain a statement thereof.

Money statement.

July 1, 1879, amount available	$12,349 92	
Amount appropriated by act approved June 14, 1880	4,000 00	
		$16,349 92
July 1, 1880, amount expended during fiscal year	345 92	
July 1, 1880, outstanding liabilities	5,700 00	
		6,045 92
July 1, 1880, amount available		10,304 00
Amount (estimated) required for completion of existing project		29,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		29,500 00

RESURVEY OF TRINITY RIVER, TEXAS, FROM ITS MOUTH TO THE BRIDGE OF THE GREAT NORTHERN RAILROAD.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., March 20, 1880.

GENERAL: I have the honor to submit the following report on resurvey of Trinity River, Texas, from its mouth to the bridge of the Great Northern Railroad.

This survey was made in pursuance of the act of Congress approved March 3, 1879, by Mr. W. L. Webb, assistant engineer, under the immediate supervision of Capt. C. E. L. B. Davis, Corps of Engineers. Begun in September, 1879, the field work was completed in November.

The object of the survey was to determine the improvements necessary to be made to open the river to navigation, and thereby accommodate and increase the commerce of the region through which the river runs.

Mr. Webb's report shows that above Liberty, the head of tide-water, and 41 miles from its mouth, no sufficient improvements can be made except at a cost out of all proportion to the importance of the interests to be benefited, the river being a succession of rocky or gravel shoals,

with deep pools between, very tortuous, with abrupt bends, and filled with snags which become waterlogged and are not carried off during the high stage of the river. Below, the character of the river changes entirely. Between Liberty and Moss Bluff it varies in width from 200 to 275 feet, and in depth from 5 to 30 feet, with the exception of a bar with 2 feet water over it 4½ miles below Liberty. From Moss Bluff to the mouth of the river it opens out to 500 feet in width and a depth of from 10 to 45 feet, free from any obstruction.

The river flows into Galveston Bay through four principal channels and a number of small bayous.

Two appropriations have been made for improving the mouth of the river; one of $10,000 in 1878-'79, and one of $2,500 in 1879-'80; and the work of deepening one of the channels over the bar has been put out to contract, and will soon be executed. There will only remain, then, to be done to give 5 feet of water at all times to Liberty, the cutting out of the bar 4½ miles below the town.

The following estimate is given:

Length of cut, 600 feet; average depth of cut, 2 feet; cubic yards of excavation, 3,511.

This is a small amount, and if it could be removed while the contractor has his dredge at the mouth of the river, it could be done at a small cost, say, 50 cents a yard, or $1,755.50.

No commercial statistics.

The work is located in the collection district of Galveston. The nearest light-house, Red Fish Bar, Galveston Harbor.

Very respectfully, your obedient servant,

S. M. MANSFIELD,
Major of Engineers,
Bvt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. W. L. WEBB, ASSISTANT ENGINEER.

BOLIVAR POINT, TEX., *January* 29, 1880.

CAPTAIN: I have the honor to submit the following report on the survey of the Trinity River, Texas, from the crossing of the International and Great Northern Railroad to the mouth of the river, made under your direction, from September 19 to November 8, 1879.

On September 25, 1879, I arrived at Riverside, Walker County, the initial point of the survey. September 27 the boats and supplies for the survey were received, and work was begun on the 28th. The appropriation for the survey being small, only a compass and stadia line was run, angles being measured from the magnetic meridian. The river was at extreme low-water stage, not navigable in places for our light skiffs, and every obstruction to navigation was in full view. During the survey the river rose a few inches, and then fell again to about its former stage.

September 28, a cross-section was made at the International and Great Northern Railroad bridge, but the velocity was so small and floats were so much influenced by the wind that the discharge could not be determined. Twelve miles below, the amount of water flowing in the river was found to be about 60 cubic feet per second. This amount was slightly increased lower down by creeks and springs.

GENERAL DESCRIPTION OF THE RIVER.

From the crossing of the International and Great Northern Railroad the river flows in a southeasterly direction to Marianna, thence south by east to its mouth. At the International and Great Northern Railroad bridge it is the boundary between Walker and Trinity counties. Then it flows between Trinity and San Jacinto, and San Jacinto and Polk counties, then through the center of Liberty County, and through Chambers County into Galveston Bay.

The river flows through a heavily-timbered valley 2 or 3 miles in width, bordered by abrupt bluffs usually covered with pine forests. At high-water it usually overflows one of its banks, and at places both. The height of high-water above low-water at the International and Great Northern Railroad bridge is 44.6 feet. This difference is gradually lessened at an almost uniform rate of 0.15 foot per mile until the head of tide-water is reached at Liberty, high-water there being 22.8 feet above low-water. From Liberty to the mouth of the river it diminishes at the rate of 0.6 foot per mile. The river usually begins to rise in September and reaches its height in February. From Riverside to Chalk Bluff the river is about 125 feet wide and from 6 inches to 30 feet deep, being a succession of rocky and gravel shoals with deep currentless portions between. The bends are large and the banks are worn very little.

From Chalk Bluff to Liberty the river is from 150 to 250 feet in width, with the same succession of deep portions and shoals as in the upper part, the shoals being sand deposits with very short distances between. The river is very tortuous, with abrupt bends, exposing its banks alternately to the action of the current. The banks at high-water are worn away on one side and built out on the other, and, as they are covered with timber, immense quantities are drawn into the river. Trees are undermined and soon fill the bends with snags which become waterlogged and are not carried off during the high stage of the river. Any improvement of this part of the river should include the girdling or cutting away of timber along the concave banks. There is an average of one tree 1¼ foot in diameter to every 30 feet square. The concave banks are almost vertical, while the opposite bank frequently has a slope of 1 to 10. At these bends the water surface at low-water is from 50 feet to 100 feet wide.

Several cut-offs have been formed in this part of the river, and one is now partly made. (See map, sheet No. 4.) It is 1,250 feet in a direct line from the upper to the lower end of this cut-off. It leaves the channel above and comes into that below at right angles. The banks are about 20 feet in height above low-water. High-water rises 25.6 feet above low-water, and 5 feet higher than the bank. The channel of the cut-off is 90 feet wide at its upper end and 50 feet at the lower end, and is a succession of pools 50 feet to 75 feet in length, and 15 feet to 20 feet deep, with narrow partitions or dams between, which are 20 feet to 25 feet thick, measured in the direction of the current, and which rise 3 feet to 4 feet above low-water. At the time of the survey no water was flowing into the cut-off, it being separated from the river by banks 3 feet and 6 feet high at its upper and lower ends, respectively. Half a dozen trees, a foot in diameter, growing on the bank at the upper end prevent any drift from entering the cut-off.

Half a mile above this cut-off there is a width of about 120 feet between two portions of the river, which is being constantly diminished by caving on each side.

At Liberty, 41 miles above its mouth, the river is affected by the tide and changes its character entirely. Between Liberty and Moss Bluff it is from 200 to 275 feet in width and 5 feet to 30 feet in depth, with the exception of one place where only 2 feet was found for a distance of 200 feet. There are few snags, the banks are worn very little, and uncovered sand bars are found only near Liberty. It however continues very tortuous.

From Moss Bluff to its mouth, it is 200 feet to 500 feet wide and 10 feet to 45 feet deep, a clear open channel free from obstruction of every kind.

At its mouth the river flows into Galveston Bay through four principal channels, Southwest, Middle, and Anderson Passes, and the "Canal" and a number of small bayous.

TOWNS.

Riverside, Walker County, at the crossing of the International and Great Northern Railroad, has 3 stores, a cotton-seed-oil mill capable of producing 50 barrels of oil per day, and 3 dwellings. There is a stone quarry here worked by the International and Great Northern Railroad Company, from which a soft sandstone, excellent for building purposes is obtained in abundance; 1,056 bales of cotton were shipped in 1878, and about 800 bales of the crop of 1879 will be shipped, all of it going by way of the International and Great Northern Railroad. An average of 1,000,000 feet, board measure, of lumber is shipped per month from a saw-mill 1½ miles north of Riverside. No steamboat has been at this place since 1870.

Newport, Walker County, on the west bank of the river, 2½ miles below Riverside, has a store and 2 dwelling-houses. There is a public ferry here.

The site of Sevastopol is marked by the ruins of a warehouse.

In January, 1878, the steamer Wren went up to Ryan's Ferry, 17 miles below Riverside, and took off a load of cotton. No steamboat has been that high up since. In 1879, 600 bales of cotton were carried down the river without steam power, on a barge built at the ferry.

Swartwout, Polk County, on the east bank of the river, has 4 dwelling-houses. No business is done here.

Marianna, Polk County, 75 miles below Riverside and 82 miles above Liberty, has 3

stores, a school-house and warehouse, and 5 residences. While steamboats were navigating the river it was the most important place above Liberty. In 1879, 75 bales of cotton were floated down the river on a flat-boat. The steamer Van Buskirk made two trips to this place, one in January and another in April, 1879, taking off 450 bales of cotton. On the first trip she was detained one month, and on the second two months, by the falling of the river. The Houston, East and West Texas Narrow-gauge Railroad, now under construction, crosses the Trinity River 4½ miles above Marianna. It will be completed to Goodwich, 7 miles north of Marianna, by July 1, 1880, and will carry off all the cotton from that vicinity, as farmers have to sell as early as possible and cannot depend upon a rise in the river.

Liberty, county seat of Liberty County, 1 mile west of the river and 41 miles above its mouth, on the Texas and New Orleans Railroad, is by far the most important place on the river. It has 300 inhabitants, 9 stores, and is surrounded by a thickly settled country. An average of 1,500 bales of cotton is shipped per annum over the railroad, all of which would go by boats if the river were free from obstruction. Sugar-cane is raised in small quantities, and 6 or 8 small sugar-mills in the vicinity supply the surrounding country with sugar and molasses. It is the head of tide-water, and the river is usually navigable to this place from October 1 to June 1, if boats could get over the bar at at the month of the river.

Moss Bluff, 21 miles below Liberty, has a store and post-office and 2 dwellings, and ships 100 bales of cotton per annum down the river on schooners. These schooners also carry cord-wood and lumber from above and below Moss Bluff.

Wallisville, the county seat of Chambers County, 6 miles above the mouth of the river, has 2 stores, a post-office, and steam cotton gin, and about 200 inhabitants. About 300 bales of cotton are shipped per annum per schooners.

The products of the valley and adjacent country are cotton, corn, sugar-cane, and lumber. Cotton receives more attention than any other crop, and is cultivated with success. Near the mouth of the river sea-island cotton is produced. The valley is covered with forests of oak, gum, walnut, cypress, and other timber, and the adjacent hills are covered with pine. First-class building stone is found in the vicinity of Riverside.

The chief exports of the valley are cotton, cord-wood, and lumber. The cane used in the gabionnade now under construction at the entrance to Galveston Harbor is obtained from the banks of the Trinity and transported to Bolivar Point in schooners.

One steamboat was engaged in the river trade in 1879, but is not expected to resume the trade in 1880.

IMPROVEMENTS.

Below Liberty the only improvements needed to produce a channel 75 feet wide and 5 feet deep at low tide are the dredging of a sand bar 4½ miles below Liberty and the bar at the mouth of the river and the removal of about 30 snags.

The estimates of material to be excavated are:

For the sand bar.—Length of cut, 600 feet; average depth, 2.0 feet; cubic yards of excavation, 3,511.

For the mouth of the Middle Pass.—Length of cut, 2,200 feet; average depth, 1.7 feet: cubic yards of excavation, 9,719.

Above Liberty the improvements will consist of removing snags and cutting down or girdling trees on the concave banks. The snags will average 25 per mile, and the trees on the bank 1 tree to 30 feet square.

Respectfully,

W. L. WEBB,
Assistant Engineer.

Capt. C. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

N 5.

IMPROVING CHANNEL OVER BAR AT MOUTH OF BRAZOS RIVER, TEXAS.

Report of Chief of Engineers for 1875, Appendix S 8, pp. 929–941, describes the entrance and gives plans and estimates for the improvement of the channel over bar.

The Brazos River debouches into the Gulf of Mexico through a single natural outlet. * * *

The river preserves a nearly uniform width and depth from the coast for several

miles up stream, the width averaging from 500 to 600 feet, the depth from 15 to 18 feet.

The bed of the river is soft mud; the banks, except at a few points, are above overflow.

At the mouth a bar has been formed, composed of sand overlying a bed of blue clay in position.

* * * * * * * *

The crest of the bar is about three-eighths of a mile from the shore line. * * *
The depth of water available for crossing is ordinarily between 7 and 8 feet. * * *

RECOMMENDATIONS.

Construction of two jetties starting from the headlands at the mouth of the river, following the sides of the natural channel across the bar, and converging so as to give an opening between their heads on the crest of the bar of about 400 feet. The greatest length to be given each jetty, five-eighths of a mile.

APPROXIMATE ESTIMATE.

Palmetto piles, 1 foot diameter, 15 feet long	6,000
Palmetto piles, 1 foot diameter, 30 feet long	4,000
Linear feet yellow-pine stringers, 8 by 12 inches	8,000
Linear feet yellow-pine anchor-piles, 8 by 12 inches	14,000
Cubic yards stone	20,000
Cubic yards fascines	20,000
Pounds bolts	30,000

Total cost, $286,484.

EFFECTS TO BE CAUSED BY THE JETTIES.

1st. Concentration of river-discharge directly on the bar, with increased velocity of current, causing erosion of a deeper channel.

2d. Deepening of river-bed for several miles above the bar.

3d. The accumulation of sand behind the jetties, thereby extending the headlands at the river's mouth.

4th. A slow extension of the bar gulfward, necessitating in the course of time an extension of the jetties.

In addition to the estimate of $286,484, as above given, attention is invited to Report of Chief of Engineers, pp. 938–946, 1879.

The first appropriation for this point, applicable to improving channel over bar at mouth of Brazos River, Texas, including a report upon the capacity of the harbor at the mouth of the Brazos and its adaptability as a harbor of refuge and naval station, $40,000, was made by act of Congress approved June 14, 1880.

PROBABLE OPERATIONS OF THE YEAR 1880–'81.

The report upon the capacity of the harbor and its adaptability as a harbor of refuge and naval station will be rendered immediately after the examination, &c., necessary is made.

Actual work—improvement of the harbor—will commence early this fall, and an excellent beginning can be made here with the funds now made available.

Original estimate (incomplete)	$286,484
Appropriated	40,000
Unappropriated balance	246,484

Of which amount $100,000 can be profitably expended in constructing jetties during the fiscal year ending June 30, 1882.

The work is not considered as susceptible of permanent completion, and estimates will vary accordingly.

It is located in the collection district of Galveston, and the nearest light house is at entrance to Galveston Harbor.

Money statement.

Amount appropriated by act approved June 14, 1880	$40,000 00
July 1, 1880, amount available	40,000 00
Amount (estimated) required for completion of existing project	246,484 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	100,000 00

N 7.

IMPROVEMENT OF PASS CAVALLO INLET TO MATAGORDA BAY, TEXAS.

First survey made in 1871; report rendered May 2, 1871.

Second survey, "at the entrance of Matagorda Bay and the channel to Indianola, Tex.," was made in 1873, and report forwarded February 4, 1874; recommendations, &c., for a system of training walls and jetties (gabion structure), to insure a single channel across the bar with a depth of 18 or 20 feet, and a width of from 500 to 1,000 feet. Estimate, $715,315.

Appropriated, August 14, 1876	$20,000
Appropriated, June 18, 1878	25,000

Re-examination of the pass was made between August 21 and September 23, 1878; from report of which the officer in charge concluded. April 12, 1879, to recommend that the subject of improvement of this pass (with the funds available, $70,000) be laid before a Board of Engineers. Report of Board (convened by Special Order No. 63, headquarters Corps of Engineers, 1879) recommends:

1. Construction of one jetty, starting from the head of Matagorda Island and running in a southeasterly direction; and,

2. For construction of groins to protect the shores where protection becomes necessary.

Object of jetty, to obtain a depth of 12 feet over the bar.

ESTIMATE.

Jetty 1,000 feet, 6 feet high, 7½ feet wide at top, at $36	$36,000
Jetty 6,550 feet, 10 feet high, 20 feet wide at top, at $100	655,000
	691,000
Contingencies, 10 per cent	69,100
Total	760,100

Groins for shore protection.

5,400 feet on shore, at $3	$16,200
6,600 feet, at $36	237,600
	253,800
Contingencies, 10 per cent	25,380
Total	279,180

See report of Board of Engineers for 1879, published herewith.

PROGRESS MADE DURING THE YEAR ENDING JUNE 30, 1880.

Preparing for the conduct of the work outlined by the Board of Engineers, under the several appropriations given—

August 14, 1876	$20,000
June 18, 1878	25,000
March 3, 1879	25,000
June 14, 1880	50,000
Aggregate	120,000

PROPOSED OPERATIONS FOR THE YEAR 1880–'81.

Construction of works in the manner planned by the Engineer Board, to the extent of available funds, by contract, after inviting proposals in the usual manner.

Original estimate (1879)	$1,039,180
Appropriated (1876–'80)	120,000
Unappropriated balance	919,180

Of which sum $200,000 can be profitably expended during the year, in constructing the works of improvement projected.

The work is located in the collection district of Indianola, Tex., and near Matagorda light-house.

Money statement.

July 1, 1879, amount available	$67,668 59	
Amount appropriated by act approved June 14, 1880	50,000 00	
		$117,668 59
July 1, 1880, amount expended during fiscal year		536 79
July 1, 1880, amount available		117,131 80
Amount (estimated) required for completion of existing project		919,180 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		200,000 00

N 8.

IMPROVEMENT OF ARANSAS PASS AND BAY UP TO ROCKPORT AND CORPUS CHRISTI, TEXAS.

In 1871 survey was made, report of which was rendered April 1, 1871.

In 1878 a "survey of Aransas Pass and Bay up to Rockport and Corpus Christi Pass and Channel" was made. Plans and estimates for improvement were rendered February 1, 1879.

Estimate (for outer bar and protection of Mustang Island)	$186,845 00
Estimate (for inside work, dam, dredging, &c.)	441,537 75
Appropriated March 3, 1879	35,000 00

The subject of the improvement of this pass and bay was referred to a Board of Engineers, and their report, dated August 9, 1879, published herewith, gives all attainable information. They submit projects and estimates as follows:

Parallel jetties from the south end of Saint Joseph's Island and the north end of Mustang Island, contracting width of water-way, and carried out a sufficient distance to afford a draught of 12 feet at mean low-

water over the bar, and of groins for the protection of the head of Mustang Island up to and beyond Turtle Cove, in conjunction with a beach-flooring of mattresses.

ESTIMATES.

For the Pass.

North jetty	$344,000
South jetty	293,950
Groins	26,400
Shore protection	24,000
Contingencies, 10 per cent	68,835
Planting trees on Saint Joseph's Island	2,000
Aggregate	759,185

For the Bay.

(Major Howell's report, 1879 .... $441,537 75)

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1880.

Preliminary measures for the conduct of the work of improvement, as outlined by the Board of Engineers, were taken early in April, and during May and June the work proceeded fairly satisfactorily.

The principal hinderance to rapid progress was the delay experienced in procuring material, owing to the general bad weather along the coast and the unusually high stage of water at the pass and in the bay. Preparatory arrangements for the constant supply of stone, brush, &c., to be furnished were made, and now that accommodations are in complete order for the working-force it is expected that work upon the improvement of the pass will proceed rapidly to the exhaustion of funds available for expenditure—appropriation of 1879—in doing work by hired labor and purchasing materials in open market.

There were constructed two frame buildings, viz, one lodging and boarding house (for the employés) and one office (for use of assistant in charge), also the necessary accessiories required.

On June 17 the work on Harbor Island jetty was commenced, mattresses constructed *in situ* in shallow water (18 to 24 to 30 inches where they are to remain), from thence out into deep water; mattresses to be placed in regular manner, viz, constructed on platform, launched, towed to place, and then sunk as required.

A forming platform for construction is well under way and will be ready for work the early part of July.

PROBABLE OPERATIONS OF THE YEAR ENDING JUNE 30, 1881.

Continuation of work in accordance with the views expressed by the Board of Engineers, the method of procedure, &c., being subject to "approved modifications" during the continuance of the work.

The $35,000 appropriated in 1879 will be exhausted in work done by hired labor and purchase of material in open market.

The $65,000 appropriated in 1880 will be applied to continuing work by contract after inviting proposals in the usual way.

Original estimate (1879)	$1,200,722 75
Appropriated (1879–'80)	100,000 00
Total	1,100,722 75

Of this amount $200,000 can be very profitably expended in the fiscal year ending June 30, 1882, in constructing jetties, &c., in accordance with approved plans for the improvement of the pass.

STATISTICS.

The letter of June 30, 1880, with accompanying papers, 1 to 7 inclusive, from Col. Thomas S. Sedgwick, my assistant in immediate charge of the work of improvement at Aransas Pass, is given herewith; also attached hereto is a copy of a letter of recent date (June, 1880) received from Mr. G. W. Fulton.

The work is located in the collection district of Corpus Christi, and the nearest light-house is at Aransas Pass.

Money statement.

July 1, 1879, amount available	$35,000 00	
Amount appropriated by act approved June 14, 1880	65,000 00	
		$100,000 00
July 1, 1880, amount expended during fiscal year	5,694 99	
July 1, 1880, outstanding liabilities	2,000 00	
		7,694 99
July 1, 1880, amount available		92,305 01
Amount (estimated) required for completion of existing project		1,100,722 75
Amount that can be profitably expended in fiscal year ending June 30, 1882.		200,000 00

COMMERCIAL STATISTICS, ETC.—REPORT OF MR. THOMAS S. SEDGWICK, ASSISTANT ENGINEER.

ARANSAS PASS, TEXAS, *June* 30, 1880.

SIR: I have the honor to transmit the following tables of statistics of commerce and trade of the bays entered from this pass and the towns thereon:

CORPUS CHRISTI CUSTOM-HOUSE.

1. Statement of arrival of vessels.
2. Statement of entries of vessels and tonnage inside.
3. Statement of vessels entered and cleared via Pass.
4. Shipments and receipts over Corpus Christi Wharf Company's Wharf.
5. Shipment of cattle by Coleman & Fulton at Rockport.
6. Products shipped by Boston Beef-Packing Company, Fulton.
7. Arrival and departures at Aransas Pass, and average stage of water.

The statement of Mr. E. F. Mercer is very interesting as showing the average stage of water on the bar for each month for the last five years, and his remarks in regard to the character of vessels arriving and departing as the water on the bar decreased. From November, 1879, to June, 1880, inclusive, there have been no arrivals of steamers regularly in trade, those arriving and departing in February and March being an "occasional" regular steamship and a steam combined four-masted schooner (the Sidbury) built for this special trade, now running, classed as sail.

Statement No. 1 shows a great falling off of arrivals via the Pass, and a corresponding increase of arrivals from inside coastwise waters.

Statement No. 2 shows the greatly increased business for inside ports from 4 entries and no clearances in 1878 to 141 entries and 62 clearances in 1879.

Statement No. 3 shows a decrease of tonnage from 70,768 tons in 1877 to 47,729 in 1878, and to 3,276 in 1879, a decrease of 95 per cent. in two years in both entries and clearances.

Statement No. 2 shows the corresponding increase.

Statement No. 4, with letter of Mr. Doddridge, explains that the change of tonnage and character of vessels, as stated by Pilot Mercer, has cost the commerce of Corpus Christi alone $65,000 for the past year.

Statement No. 5 shows that the business of Coleman & Fulton has gradually de-

creased to 1877, and is now suspended from this port. Rockport is almost deserted in business.

Statement No. 6 shows the effect on the industries established here under the most favorable circumstances. It is doubtful whether the Boston Beef-Packing and Canning Company will resume operations until there is an increased depth of water on the bar.

Statement No. 7 shows that while the depth of water on the bar was 8 feet and more, the average arrivals of steam vessels was 6, 7, or 8 per month—about two each week, indicating the regular demand for steam transportation. You will further observe that as the bar shoaled to a depth below 8 feet there was a marked falling off of business per steam vessels. They seemed loth to abandon the trade, and held on while there were 7½ and 7 feet of water, evidently hoping for some favorable change on the bar.

This feature is instructive, as showing that 8 feet of water on the bar has been sufficient for the demands of commerce.

The greater number of arrivals and departures of steam vessels during the months of September, October, November, and December, 1877, indicate a promised and increased commerce for these bays, which was disappointed because of the shoaling of the bar to 7½ feet.

The increase of water on the bar from 8½ to 11 feet was caused by a severe northwester that blew on the 16th of September, 1875, accompanied with such heavy rainfall that a fire could not be kept up in a common fire-place.

The channel then made held about the same relative position with the north end of Mustang Island as does the present one.

I am, very respectfully, your obedient servant,

THOMAS S. SEDGWICK,
Assistant Engineer.

Maj. S. M. MANSFIELD,
Corps of Engineers.

List of arrivals of vessels at port of Corpus Christi, Tex., from January, 1876, to June, 1880, inclusive.

Total for year.	Through Aransas Pass.		From inside.		Remarks.
	No.	Tonnage.	No.	Tonnage.	
1876	150	51, 557	309	5, 093	
1877	188	75, 065	434	6, 745	
1878	177	48, 257	402	6, 609	
1879	137	7, 867	608	10, 463	
1880	68	11, 351	251	4, 874	Only for six months.
Total	726	194, 097	2, 004	33, 784	

Statement of vessels and their tonnage entered and cleared at Corpus Christi, Tex., for inside ports, from January, 1876, to June, 1880, inclusive.

Total for year.	Entered.		Cleared.		Remarks.
	No.	Tonnage.	No.	Tonnage.	
1876	5	80	5	80	
1877					No transactions.
1878	4	62			No clearances
1879	141	3, 025	62	1, 240	
1880	74	1, 813	26	652	Only for six months
Total	224	4, 980	93	1, 972	

Statement of vessels and their tonnage entered and cleared at Corpus Christi, Tex., via Aransas Pass, from January, 1876, to June, 1880, inclusive.

Total for year.	Entered.		Cleared.		Remarks.
	No.	Tonnage.	No.	Tonnage.	
1876	69	46,401	70	47,415	
1877	100	70,768	84	56,882	
1878	79	47,729	57	35,346	
1879	61	3,276	34	2,325	
1880	32	9,005	9	6,718	Only for six months.
Total	341	177,179	254	148,686	

LETTER OF CORPUS CHRISTI WHARF AND WAREHOUSE COMPANY.

CORPUS CHRISTI, TEX., *June* 28, 1880.

DEAR SIR: I herewith inclose you a statement of receipts and shipments over our wharves for the last year.

Before the closing of Aransas Bar all this freight came and went by that route, but, owing to the closing of the bar, most of it now goes by lighters through the bays to Indianola for shipment, at an additional cost to the producer and consumer of about 15 cents per 100 pounds, say $3 per ton on the whole, as what few vessels now cross the bar are of light draught and small carrying capacity, and charge a much higher rate of freight than we formerly had while the bar was open and we could get a larger class of vessels and steamers in.

The rates of lighterage since I gave a former report to Hon. C. Upson, M. C., from our district, have been reduced, so that we now pay 15 cents per 100 pounds instead of 25 cents at that time.

I estimate the actual extra expense for this year, for above reasons, at about $65,000 for goods shipped to and from Corpus Christi.

Yours, respectfully,

P. DODDRIDGE,
Treasurer Corpus Christi Wharf and Warehouse Company.

Col. THOS. S. SEDGWICK.

ceipts and shipments over the wharves of Corpus Christi, Tex., from July 1, 1879, *to June* 28, 1880.

Articles.	Quantity.
SHIPMENTS.	
Wool .... pounds..	6,500,000
Hides, green salted .... number..	1,700
Bones .... tons..	154
Kips, dry .... pounds..	177,000
Sheep .... head..	300
Hides, dry .... number..	65,000
Skins .... pounds..	792,000
Horse-hair .... do....	42,000
Tallow .... barrels..	65
RECEIPTS.	
Merchandise .... barrels..	120,000
Lumber .... feet..	4,500,000
Shingles .... number..	1,500,000

P. DODDRIDGE,
Treasurer Corpus Christi Wharf and Warehouse Company.

LETTER OF MESSRS. COLEMAN & FULTON.

ROCKPORT, TEX., *June* 30, 1880.

SIR: In accordance with your request we hand you herewith the total number of cattle shipped from this port for New Orleans. This constitutes about one-third of our entire shipments, the balance having been shipped from Indianola, principally to Cuba.

From this port for New Orleans, say—

	Head.
1873	23,000
1874	26,000
1875	21,600
1876	18,300
1877	15,700
Total	104,600

In 1878 a very few cattle were shipped—only one load—and since then we have been completely shut in from the world in consequence of the closing of the bar.

Yours, truly,

COLEMAN & FULTON.

Col. THOS. S. SEDGWICK.

LETTER OF BOSTON BEEF-PACKING COMPANY.

FULTON, TEX., *June* 25, 1880.

COLONEL: By request of Col. G. W. Fulton we inclose herewith statement showing the amount of our exports and imports and the effect of the shoaling of Aransas Pass Bar on our business.

Very respectfully,

BOSTON BEEF-PACKING COMPANY,
G. M. COX.

Col. THOS. SEDGWICK.

Statement of production of Boston Beef-Packing Company at Fulton, Aransas County, Texas, for the season of 1879–'80, *exported through Aransas Pass.*

Articles.	Quantity.	Articles.	Quantity.
Hides .... pounds..	1,246,200	Shin-bones .... pounds..	49,848
Calf-skins .... do....	8,526	Knuckles .... do....	28,039
Tallow .... do....	1,142,350	Hair .... do....	3,530
Beef (in tin) .... do....	2,492,400	Tankings .... do....	830,800
Tongue (in tin) .... do....	31,155		
Neat's-foot oil .... do....	12,800	Total	5,984,807
Blood .... do....	83,080		
Rethes .... do....	35,309	Horns .... number..	41,540
Hoofs .... do....	20,770		

The cost of freight and extra charges (necessitated by indirect communication), the excess of what we paid during the season of 1877 and 1878, has been about $20,000, and in addition thereto we have had to build extra warehouses for the storage of coarse products, the profit on which will not admit of the payment of heavy freights caused by the shoaling of the bar.

We have now on hand over a million pounds of fertilizers, &c., awaiting favorable charter.

Our imports of supplies for the season amounted to about 2,500,000 pounds.

LETTER OF MR. ED. T. MERCER, BRANCH PILOT, ARANSAS BAR.

ARANSAS PASS, TEXAS, *June* 30, 1880.

I have the pleasure to hand you herewith a statement of the arrivals and departures over this bar for the last five years, together with the average depth of water during that time, taken from log-book kept at this station.

I respectfully direct your attention to the difference of tonnage at the time the bar afforded from 8 feet and upwards and then when the bar shoaled to 7½ feet.

When we had from 8 to 10 feet, the steamships were of the Morgan line, and others, carrying from 3,000 to 5,000 barrels of merchandise, inward and outward, full cargoes of wool, hides, canned meats, and live-stock, drawing from 8 to 9 feet; the said vessels trading from New York, Boston, Philadelphia, and other ports, were from 200 to

300 tons, carrying cargoes of merchandise inward on draft of from 8 to 10 feet, and full cargoes outward on 8 to 9 feet; also a number of large sailing vessels employed in the lumber trade on draft of 8 to 9 feet.

When the bar shoaled to 7½ feet, the large steamships and sailing vessels were compelled to haul off from the trade, and ones of lighter draft were used until the bar shoaled to 6 feet, when all the steamships hauled off, also the sailing vessels, only those of very light draft, of the capacity of 300 to 1,000 barrels.

The lumber trade was changed to small coasters of from 20,000 to 70,000 feet capacity, and the bar at the present time can be crossed only when very smooth.

Yours, respectfully,

ED. T. MERCER,
Branch Pilot, Aransas Bar.

Col. THOS. S. SEDGWICK,
Assistant Engineer.

Table of arrivals and departures of vessels at Aransas Pass, Texas, from July, 1876, to June, 1880, inclusive.

Month.	1876.					1877.					1878.					1879.					1880.				
	Steam.		Sail.			Steam.		Sail.			Steam.		Sail.			Steam.		Sail.			Steam.		Sail.		
	Arrivals.	Departures.	Arrivals.	Departures.	Average depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Average depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Average depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Average depth of water on bar.	Arrivals.	Departures.	Arrivals.	Departures.	Average depth of water on bar.
July	6	6	11	12	8½	6	7	11	12	10	6	6	16	13	9	4	4	13	13	7	......	......	2	9	5
August	7	7	19	18	8½	7	7	17	18	10	7	9	12	13	9	1	1	16	9	7	......	......	13	10	5
September ...	8	7	8	9	11	8	7	8	9	10	11	10	15	18	8½	2	2	6	11	7	......	......	11	13	5
October	7	6	16	13	11	7	6	13	13	10	13	14	19	16	8	3	2	2	1	7	......	......	12	11	5½
November.....	7	8	11	12	11	7	8	11	12	10	10	9	13	15	8	2	3	12	9	7	......	......	15	8	5½
December	8	7	17	13	11	8	7	18	13	9½	11	10	8	12	7½	......	......	10	5	5½	......	......	13	20	5½
January.......	6	6	8	11	11	6	6	8	11	9½	7	8	20	17	7½	......	......	12	10	5	......	......	14	16	6
February	6	5	12	13	11	6	5	12	13	9½	7	4	20	14	7½	......	......	16	19	5	3	2	11	8	6
March.........	3	4	13	11	11	4	5	12	10	9½	6	7	12	20	7½	......	......	23	22	5	2	3	6	9	6
April..........	6	7	26	20	10½	3	3	11	7	9½	3	5	10	11	7½	......	......	21	19	5½	......	......	10	5	6
May...........	9	8	10	13	10½	7	5	9	16	9½	4	3	22	23	7½	......	......	11	8	5½	......	......	28	28	6
June	8	8	13	11	10	5	6	15	15	9	3	4	17	14	7½	......	......	14	14	5½	......	......	12	10	6
Total.....	91	79	164	156	......	74	62	145	149	......	88	89	184	186	......	12	12	156	140	......	5	5	147	147	......

LETTER OF MR. G. W. FULTON.

FULTON, TEX., *June* —, 1880.

DEAR SIR: The interest evinced by you in your favor of 11th instant for the successful prosecution of the improvement of Aransas Pass, now under your charge, induces me to lay before you my views of the importance of that work with regard to local as well as national interests.

In the years 1837-'38 and '39, in the two latter as collector of customs for this district under the Republic of Texas, I became intimately acquainted with its condition at that time, when vessels drawing 12 to 14 feet passed over safely, and became fully convinced of its future importance to the commerce of a large area of country then almost uninhabited, and the land, except along river and bay fronts, exclusively the property of the State. Now there is scarcely an acre of public land within an area of 200 miles from this point as a center, and the country is rapidly settling beyond toward the Upper Rio Grande, which, from its mouth in latitude 26° to a point due west from here in latitude 28°, does not vary 20 miles from the quadrant of a circle of 200 miles radius. Beyond that point the Rio Grande stretches to the northwest and the Gulf coast to the northeast, whereby Aransas remains the focal point of the vast region to El Paso and beyond.

Aransas is the central point of the great cattle-producing country of West Texas. Between 1868, at which time the writer returned to Texas, and the closing of the bar in 1878, at least half a million head of cattle, either alive or slaughtered, passed over the bar; also, great numbers of horses, sheep, and hogs, as well as the large wool clip of West Texas, and the hides, wool, lead, &c., of Mexico, and the return cargoes for that market; also, a large lumber trade and general supplies for the surrounding country for one hundred miles north and west to the Rio Grande. Since then this large cattle business has dwindled to the extent of corned meat from one establishment, the Boston Beef-Packing Company, at this place, which has been obliged to bear the extra expense of lighterage to Indianola or Galveston upon its large operations, and the wool and Mexican trade of Corpus Christi has been likewise overburdened and injured. Of the future of the region depending upon Aransas Pass for an outlet, I would remark that, in my opinion, it is destined to become one of the best agricultural districts in the South. In former times it acquired the name of being "only fit for pasturage." This was owing to the fact that what little attempt at farming was made was by small farmers, whose greater interest was in their herds, that demanded their exclusive attention at a time that should have been exclusively given to their crops, which, in consequence, were universally smothered with rank weeds upon their return from the spring branding, the growth of weeds shoring the strength of the ground, which, under proper culture, would have produced remunerative crops. Within the last decade there has been a great revolution going on, that, like all revolutions, was looked upon with small favor by those accustomed to the former order of things, but which in moral and industrial effects upon the country is only now beginning to be understood and realized. I allude to the fact that almost the entire radius above described around Aransas has been inclosed in large pastures from 10,000 to 200,000 acres each. Instead of the former abortive efforts at farming, the pasture owners are, by proper tillage, proving that good and regular crops may be depended upon; this will lead to the establishment of farms on suitable spots now used exclusively for pasturage; these farmers will be enabled to pay for their lands from the sale of grain and forage to the cattle herders, who are now improving their stocks, and when, by the opening of Aransas Pass to foreign shipping, a home market for grain-fed beeves will be established, and the agricultural and pastoral interests of the country will be harmonized to their mutual benefit.

The moral tendency of this radical change from the former mode of herding cattle upon the common, with its annual scramble for mavericks or unbranded stock, causing the ruin of many young men, cannot be overestimated. In relating the foregoing particulars, I have endeavored to show the rapid progress of the country dependent upon Aransas Pass for its commerce with the world under its present embarrassment, and to give some idea of its capabilities, when, by the completion of the work in which you are now engaged, the restrictions opposing its further development shall have been removed. The position of Aransas as a commercial port is thus expressed by Lieutenant Maury: "The waters from every part of the Atlantic tend toward the Gulf of Mexico and its streams, and Aransas is at the point of nearest approach of the Gulf Stream to the western shore of the Gulf. This great river of the ocean is ever ready to bring and take commerce to and from this point, while the reflex current caused by its near approach will remove from before our entrance, when improved, all *débris* that might otherwise remain to obstruct it." That this littoral current is at its maximum at Aransas is well shown by the chart of the surveys of the United States, accompanying Major Howell's last report. Supposing the tendency of the outflow from each pass into still water in the Gulf would be at a right angle to the coast, the deflection shown is 20° at Sabine, 30° at Galveston, 33° at Cavallo, 68° at Aransas,

and nothing at Brazos Santiago; hence, at Aransas we have the best assurance of success for the jetty system proposed, that is, a strong littoral current. Now, in the natural condition of the pass, this strong south current continually forces the channel towards the coast of Mustang Island until, being brought at a right angle to the prevailing southeast wind, the breakers drive the sand into it, filling it up and presenting a flat in front of the pass, barring entrance until a friendly storm opens another channel directly to the east or north of east, only to follow the same routine and share the fate of its predecessor.

The future of Aransas as an Atlantic terminus of a system of railroads to the Pacific, skirting the Rio Grande and giving to the government the nearest and most direct approach from the Gulf to our Mexican border, can scarcely be overestimated. As a naval rendezvous in case of war, or a harbor of refuge in time of peace, words need not be wasted in proving its great advantage. As an engineer, I have long been impressed with its superior availabilities for improvement. The distance from 20 feet inside to 20 feet outside never exceeds three-fourths of a mile, and is often much less. During last summer the strong south current swept the outer portion of the bar away, causing 18 feet of water within a stone's throw of the wreck of the steamer Mary, and leaving a mere ridge of sand that provokingly barred our commerce with the outside world. That this natural fickleness of our bar can be more easily controlled than if it were of a more immovable nature is as clear to my mind as the fact that a strong will can easily govern a weak and unstable one, nor do I believe that the difference of the cost of 20 or more feet of water will greatly exceed that necessary to obtain 12 or 15 feet, the difference being more in position than in the magnitude of the jetties required.

The embarrassments that now surround us cause an anxiety that, in some way, quick relief may be given, and if it should be possible that this work could proceed in such a manner as to afford, say, an 8-foot channel during its progress, without greatly increasing the ultimate cost, the gratitude of a suffering community would be cheaply earned.

Thanking you for the opportunity of thus presenting my views,

I remain, with great respect, yours, very truly,

G. W. FULTON.

Maj. S. M. MANSFIELD,
United States Engineer in Charge, Texas Coast Improvement.

REPORT OF BOARD OF ENGINEERS.

ARMY BUILDING,
New York, August 9, 1879.

GENERAL: The Board of Engineers convened by the following order, viz:

[Special Orders No. 63.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., June 3, 1879.

By direction of the Secretary of War, a board of officers of the Corps of Engineers, to consist of Col Z. B. Tower, Lieut. Col. John Newton, Lieut. Col. Q. A. Gillmore, Capt. C. W. Howell, will assemble in New York City, on the call of the senior officer and as soon as other duties of members will permit, to take into consideration and report upon the improvement of Pass Cavallo Inlet into Matagorda Bay and of Aransas Pass and Bay up to Rockport and Corpus Christi, Tex.; and also the continuation of the improvement of the entrance to Galveston Harbor.

The Board is authorized to visit the localities named if considered important to do so.

H. G. WRIGHT,
Acting Chief of Engineers.

having assembled on the 1st instant, and continued their sessions as frequently as other necessary duties permitted, have the honor to submit the following report:

GENERAL REMARKS.

All of the passes and entrances submitted to the consideration of the Board agree in certain prominent features, which are due to the action of the winds and tides upon the characteristic formation of the coast.

At all of these places there are interior bays, separated from the Gulf by long, narrow islands or peninsulas, which form the exterior coast line. The water-level in these basins is daily raised and lowered by the Gulf tides, aided by the winds, and in the comparatively contracted inlets and outlets the tidal currents are strong. All of the silt brought down by the inconsiderable streams which empty into these basins is deposited before reaching the Gulf.

Besides ordinary tides of little elevation, the bays are subject to storm tides, caused by violent in-shore winds driving in large volumes of water from the Gulf. When these are followed by gales from the land the heaped-up waters are forced back through the outlets with great velocity. After such series of operations the bars are found to be in their best condition.

Along the exterior coast line the drift of sand, by the action of the currents and waves, is in the general direction from northeast to southwest. The tendencies are for the east shores of the inlets to gain towards the west, and for the west shores to recede correspondingly in the same direction.

The Board are not in possession of maps of ancient date with which to compare surveys of the present time; but such has probably been the action which in the lapse of years has placed the inlets in their present positions by a nearly continuous movement down the coast. When the inlet, as at Aransas Bay, has reached the line of the lower or southwest side of that bay, a further movement would tend to draw out and narrow the pass, which, if not arrested, might cause the inlet to be closed by the occurrence of a heavy wind from seaward forming unusual deposits across the bar. The pass into the Bay of Corpus Christi has virtually closed to navigation, apparently from the effect of the narrowing process; and it is not inappropriate here to quote from the report of Capt. George B. McClellan, formerly of the Corps of Engineers, made to the Chief of Engineers January 13, 1853, in which, narrating certain changes produced on the bars at the inlets to Aransas, Matagorda, and Corpus Christi Bay, he states of the last named, "this channel is probably closed by this time, or soon will be," showing at that early date the opinions entertained of its want of permanence. It is highly probable that Aransas Pass and Pass Cavallo have once been in the same position relative to their surroundings that the pass at Galveston now is.

The late Lieut. W. H. Stevens, Corps of Engineers, in his report of December 26, 1853, recommending a breakwater at Fort Point, Galveston Harbor, states:

> The object of this structure is to prevent the southeast gales washing the sand from the point between the east end of Galveston Island and the point marked "S. Buoy" * * * into the channel between "East End" and "Pelican Shoal," and also to force the water which now flows between the buoy and the point into the channel.
>
> I am informed that the point once extended nearly to the south buoy, and that where you see 12 feet of water in the channel a few years ago there was 30 feet, and that this shoaling has been synchronous with the washing of the point.

It is apparent from this quotation that the tendency has been to wash away the east end of Galveston Island, and for the inlet, as noticed at other points, to move down the coast, which has been prevented hitherto by artificial works, similar in position and scope to the breakwater advocated by Lieutenant Stevens.

But for such works, which the preservation of the site of the city of Galveston demanded, it is evident that the same lateral movement of the inlet which characterizes the passes into Aransas and Matagorda bays would to-day be chronicled.

The movements of the inlets and passes are due not only to wave action, but also to the direction of the interior currents in the principal channels of the bays, which strike with force upon the shores forming the west side of the passes, with eroding effects proportioned to their strength.

The width of the inlets are, for Galveston, 9,000 feet, for Pass Cavallo about the same; while for Aransas Pass the width is only 3,300 feet. As it is conceded that the depths over the bars are greatly due to the piling up of the waters within the bays by heavy winds from the seaward, and their consequent discharge, aided in velocity by the action of the northers, it would seem that the bars would be in best condition when the cross-sections of the inlets were so proportioned to the spaces to be filled as to allow a free ingress to the Gulf water, and that consequently any proposition to narrow the inlets should be carefully scrutinized, and the necessity and effects of such action clearly demonstrated.

It is not meant that every change of position of the inlets has been due solely to the causes enumerated above; obviously a change may have been effected at times by the heaped-up waters of the interior basins finding their way to the Gulf across a low level of the outer line of coast, forming thus a new outlet, and ultimately causing the old one to fill up. Such an operation could be prevented by planting the low levels with trees and bushes to accumulate sand.

From this description of influences at work, the principles of improving such bars would generally be to protect the west shore of the inlet from erosion by waves and currents, and to sustain, by jetty or by parallel jetties, the natural direction of the ebb currents over the bar, which is to the east of south or nearly southeast.

The Board are not committed to the opinion that the west shores of the inlets can be protected or the lateral movements of the channels prevented in all cases; nor do they intend to say that if such arrest of movement be obtained it would prove to be of permanent benefit; on the contrary, it is not impossible that such result might sometimes culminate in the closing of the pass itself.

The Board feel that little more can be done in this report than to point out the general principles involved in the problems presented to their consideration, for the influences at work, though they may be known, cannot be estimated for a number of years ahead as to their relative values. There have been almost no opportunities for experiences valuable as precedents along this coast, and the conditions are so variable with time that a large margin should be left to the study and intelligence of the constructing officer on the ground.

MATAGORDA INLET.

The first official report upon this channel accessible to the Board is that of Gen. George B. McClellan (at the time a lieutenant of engineers) to the Chief Engineer, U. S. A., dated January 13, 1853. Speaking of the sanguine opinions of those interested in the improvement of the bar as to the feasibility and cost, he states:

> I cannot ascertain that any well-considered plan has been proposed. I can meet with nothing but hap-hazard opinions as to the location of the proposed *breakwater*, and still wilder guesses at the cost; the fact is, I think that all consider the object as desirable and important, but that no one in any respect competent has seriously considered the proper location, cost, practicability, and effect of such a construction. * * *

He describes the bar as composed of loose shifting sand, and fully exposed to the action of great storms, the consequence being the shifting

of the channel, particularly after a storm. While engaged in the examination, it moved laterally 150 yards, having 9 feet in the new channel and leaving but 6 feet in the old. With respect to the recommendation of closing the space from Pelican Island to Decrow's Point, he considered that the effect of the southeast winds in filling the bay would be thereby decreased about three-fifths, and that in thus seeking to deepen the bar the bay might be rendered more shallow.

The great current passes close to the northwest point of the peninsula, which is cutting away, and impinges on the opposite shore nearly opposite Pelican Island, and is continually cutting away that shore.

He finally recommends, as preliminary to any project and estimate, continued observations and a careful survey.

The late Lieut. E. A. Woodruff, Corps of Engineers, made a report to Capt. C. W. Howell, Corps of Engineers, April 1, 1871, of a survey of Pass Cavallo (Report of Chief of Engineers for 1871, pp. 531, 532, 533):

It presents the same general characteristics as Aransas Pass, but on a much larger scale. Its history, like that of Aransas and Corpus Christi passes, shows a steady deterioration as a harbor and a constant shifting of the channel to the south; the historical fact of the deterioration of these harbors in the same time leads to the inference that the shoaling is due to the change of position. The general cause for the change is probably the prevalent direction of the winds, which have the greatest effect on the southern shores of the passes. The most rapid erosion has taken place during high tides accompanied by easterly winds.

Fort Esperanza, an earthwork on Matagorda Island built during the war, 100 feet from the shore, had its eastern parapet carried away by the sea in 1868.

In 1854 a remarkable storm occurred, which reduced Pelican Island to a mere sand flat, hardly above ordinary high-water. Before this storm it had grass-covered sand mounds about 20 feet high, and fresh water could be obtained by digging in the hollows. The storm began by a southeaster, which filled Matagorda and Espiritu Sancto Bays unusually full of water; then changing to the northwest, the wind drove the water of the bays through the channel and over the end of Matagorda Island and Peninsula. The direction of the channel was changed considerably to the south, and its depth increased to 13 feet; but it shoaled to 8 feet in 1856, and at present 7 feet is all that can be depended upon. * * * Every storm, however, changes the position of the system of shoals running south from Decrow's Point. * * *

Pelican Island itself has shifted its position to the north about three-quarters of a mile since the survey of 1856.

I found an idea generally prevailing among the citizens interested in the improvement of the pass that it would be easy to stop up the channel between Decrow's Point and Pelican Island, thus causing a greater current at ebb-tide to act on the bar.

Decrow's Point, and a portion of Matagorda Island opposite, are low and subject to overflow in extreme high-water. This is especially the case with Matagorda Island, where the salt water has killed the grass on about half the surface. In planting a signal-pole on this island I found that after getting through a crust of a few inches on the surface I could easily thrust the whole pole, 8 feet in length, into the earth.

The effect of any work closing Pelican Island Channel would be much more perceptible on Matagorda Island than on the bar, which at present is about three-quarters of a mile from the shore-line of the Gulf, and any attempt to narrow the inlet of Matagorda Bay without first protecting Matagorda Island by an efficient revetment would be a waste of the money expended.

Lieutenant Woodruff, specifying the work necessary for improvement, says:

This would require a jetty from Decrow's Point to the bar, a distance of 4 miles, and a revetment of Matagorda Island from Bayou McHenry to the point below the lighthouse, also a distance of 4 miles. Both of these works would be principally on quicksand foundations, and both, especially the jetties, would be exposed to seas which only a massive sea-wall could permanently resist. Small works, such as pile groins or piers, will succeed in causing an accretion of sand during the continuance of ordinary tides and weather; but a high tide with strong winds will in a few hours sweep away the accretion of months and the work which caused it. Such has actually been the history of some small pile works attempted on the Matagorda Island shore.

Lieutenant Woodruff recommended no plan of improvement for this channel, and Captain Howell indorsed his course.

Capt. George B. McClellan, reporting to Bvt. Brig. Gen. Joseph G. Totten, Chief Engineer, U. S. A. (Ex. Doc., vol. 2, 1853–'54, p. 561), says:

With regard to the project of improving Pass Cavallo by closing the Pelican Island Channel, to which my attention has been called by the department, I have, since my letter of January 13, 1853, given it an attentive consideration. * * * Were the strength of the current increased, it would exert itself in cutting away more rapidly the points of Matagorda Island where the light-house now stands and thus enable itself to spread out still more than it now does before reaching the bar. So far as it is possible to foresee the effect of so uncertain an operation, and judging principally from what I have observed at the passes in general, I think that, were any appreciable effect produced by closing the opening in question, it would be lateral rather than vertical.

Captain Howell reports to the Chief of Engineers, under date of February 4, 1874, the results of the survey in 1873, by Mr. H. C. Ripley, assistant engineer, of the entrance into Matagorda Bay and Channel to Indianola (Report of Chief of Engineers, 1874, Part I, pp. 760–765):

Pelican Island has moved north and approaches Decrow's Point nearly its entire width, thus making the Elizabeth Channel more defined and deeper, and diminishing the distance from the island to Decrow's Point from 7,440 feet to 4,180 feet.

The main channel south of Pelican Island was divided into the "Old Channel" and "Veto Channel," the latter and the more recent having become the principal entrance. The depth over the bar was 7 feet.

The bar, "like the one at Galveston, is composed of pure quicksand to a depth of from 40 to 60 feet."

Captain Howell, submitting a project with estimates, writes:

For works of this kind it is only deemed possible to submit a general plan, with suggestions as to its probable effects.

The first work recommended was the closure of Decrow's and Elizabeth channels by inducing the formation of shoals and thereby the extension of Matagorda Peninsula to include Pelican Island; among other effects, it was supposed this work would obliterate the "Old Channel," and that the "Veto Channel" would be driven southward. The depth over the bar it was thought would be 12 feet.

The next step would be two parallel dikes or structures to induce the formation of dikes, the lines being, respectively, from Matagorda Island along the southwest boundary of the channel and from Pelican Island along its northeast boundary. The estimate was as follows:

Gabionnade closing space between Pelican Island and Decrow's Point	$291,167
Gabionnade on parallel pins to bar	424,188

The closure of the space between Pelican Island and Decrow's Point it was supposed would give a depth over the bar sufficient for the wharves at Indianola, and the parallel jetties were considered advisable only to afford a depth over the bar sufficient to enter the harbor near the point marked on the chart "Saleeria."

The amount of $20,000 appropriated by act approved August 14, 1876, being considered by Captain Howell as insufficient to commence work with, he was authorized to await further appropriations. Estimate of sum needed for a commencement, $150,000. (Report of Chief of Engineers for 1877, Part I, pp. 469–471.) Amount appropriated by act approved June 18, 1878, $25,000. Authority was asked to make a new survey. (Report of Chief of Engineers for 1878, Part I, p. 613.)

Captain Howell reports to the Chief of Engineers, December 17, 1878, upon survey of that year made to determine the advisability of applying the funds available to the protection of the head of Matagorda

Island. Although the head of the island was washed away for a considerable length of beach, and to a width varying from 200 to 1,300 feet, yet the indications, as reported by Captain Howell, were not for immediate protection. Mr. Abraham Cross, the surveyor, reports as his opinion that the whole damage was done by the storms of 1875, since which time he considered the beach to have been reforming.

Other changes very remarkable were reported, Pelican Island having moved southward about 4,900 feet and the "Veto" and "Old" channels having merged into one in the prolongation of the channel above, but curving slightly to the eastward. The depth over the bar, with a long increase of width of Decrow's and Elizabeth channels, nevertheless had changed, since 1873, from 7 to over 10 feet. Captain Howell in his report states that "an appropriation of $100,000 in addition to that now available would justify commencement of the work."

APPROPRIATIONS.

August 14, 1876	$20,000
June 18, 1878	25,000
March 3, 1879	25,000
Total	70,000

PROJECT FOR MATAGORDA INLET.

Recommendations have been made to close Decrow's and Elizabeth channels, thus bringing the south end of Matagorda Peninsula to the position of Pelican Island, with the intention of increasing the depth over the bar. The Board are not prepared to say that some such effect would not be produced, but the necessity for such an extreme step does not seem to have arisen, and the result would be, by shutting up one inlet, to diminish the quantity of flood going up the bay.

Pelican Island between 1871 and 1873 moved northward its width, and from 1873 to 1875 receded southward 4,700 feet. This island may, in the future, be the nucleus of shoals which will close Decrow's Channel, and thereby take the first step towards elongating and narrowing the pass, as at Corpus Christi and Aransas bays. As the Board do not perceive the benefits to be derived from such result, but rather the reverse, they cannot recommend constructions to close this passage.

It is true that if Pelican Island should continue its southerly movement, it might become necessary to line the bed of the channel between the island and Decrow's Point with a row of mattresses to prevent an increase of water-way.

The necessity of a shore protection for the head of Matagorda Island seems, from all the papers submitted to the Board, to be in doubt, and they prefer to leave the decision of this point to the future.

A project is submitted for one jetty, starting from the head of Matagorda Island and running in a southeasterly direction, as represented on the sketch sent herewith; and also for groins to protect the shores, when this becomes necessary.

The object of the jetty is to obtain a depth of 12 feet over the bar.

ESTIMATE FOR JETTY.

1,000 feet, 6 feet high, 7½ feet wide at top, at $36	$36,000
6.550 feet, 10 feet high, 20 feet wide at top, at $100	655,000
	691,000
10 per cent. for contingencies	69,100
	760,100

GROINS FOR SHORE PROTECTION.

5,400 feet on shore, at $3	$16,200
6,600 feet on shore, at $36	237,600
	253,800
10 per cent. for contingencies	25,380
	279,180

The groin next to the jetty should be begun at the same time as the jetty.

The project submitted by the Board should not be considered as necessarily complete, or that it may not admit of revision from the light furnished by experience and continued observations.

The opinions of the various engineers who have reported upon the improvement of the pass offer occasion for wide differences as to the amount and description of the works required for the place.

The Board have attentively considered the information furnished by surveys and reports thereon, and recommend for present construction only what, by a careful comparison of data, appears to be strictly necessary for the improvement of the bar. The jetty should be high, probably throughout its entire length, as it is designed to sustain the current of the bar channel, which will, it is thought, be pressed against it by the north shoal, formed of the usual drift-sand down the coast. Should such assumption not prove to be correct, a parallel jetty on the north shoal, in co-operation with the other, would become a necessary part of the project.

The general laws of formation along this coast are perhaps well enough known, and the industry of observers have collected valuable facts, which can now be utilized, but something additional is required—the determination, by actual experience from constructed works, joined with further accurate observations, how far influences peculiar to this pass may modify general conclusions.

For these reasons the Board have confined their recommendation only to what, in their judgment, could not be dispensed with.

The Board do not consider that positions of the jetties and groins, or the number of the latter, should now be rigidly fixed; modifications in these respects would probably arise from the experience gained at the locality from a partial application of the project itself, as well as from other considerations.

It is understood that the amount available is something over $70,000, the expenditure of which sum, in the opinion of the Board, would be inadequate to produce a useful effect upon the bar.

INLETS INTO ARANSAS AND CORPUS CHRISTI BAYS.

Capt. Geo. B. McClellan's report to the Chief Engineer, U. S. A., January 13, 1853, states, with respect to this bar, that it is composed of a loose shifting sand, and exposed to change of position after heavy storms. Within a week while he was on the coast, the bar channel shifted all the way over from the north to the south breakers, having 9 feet in the new and leaving 4 feet in the old channel, three vessels being wrecked in as many days before the change was discovered; and the "Corpus Christi Bar opened at the same time to 9 feet, having but 5 feet in it before; this channel is probably closed by this time, or soon will be."

The sudden changes of the channel of Aransas Inlet appear to leave temporarily a swash channel near Saint Joseph's Island, the deeper

channel being nearer to Mustang Island, to which position it constantly tends to shift.

In the Report of the Chief of Engineers for 1871, pp. 526–531, is found the report of Capt. C. W. Howell, Corps of Engineers, transmitting the letter of the late Lieut. E. A. Woodruff, Corps of Engineers, giving the results of his survey of the bars and passes of Corpus Christi and Aransas bays.

Corpus Christi Pass or Inlet is an entrance from the Gulf of Mexico to Corpus Christi Bay, between Mustang Island on the north and Padre Island on the south. * * * The channel from the pass to Corpus Christi Bay is narrow, and bears in general direction nearly due north about 6 miles before reaching the deep water of the bay. Entering the pass from the gulf, we find the water on the bar from 5 to 7 feet, varying with the wind and tide.

He describes the pass as interrupted by shoals and bulkheads before entering into the deep water of the bay. He considers the length and tortuous course of the channel of the pass as unfavorable to the free flow of the waters of the bay over the bar and to the improvement of the latter. He calls attention to the better chances of improving the bar at Aransas Pass, and of accommodating the commerce of Corpus Christi Bay, by enlarging the communication between these bays, and diverting the course of navigation to Aransas Bar.

In regard to Aransas Pass, he states its continuous encroachment on Mustang Island (on the south) and the corresponding gain of Saint Joseph's Island:

In 1869 work was begun by private enterprise to improve the channel through the bar by running out lines of jetties from the Saint Joseph's Island shore to cut off a secondary channel near this shore. * * * They were expected to act as a nucleus, about which sand would accumulate and close up the secondary channel, thus diverting the flow of the water directly through the channel on the bar. From the fact that the secondary channel has shoaled about 2 feet and the main channel deepened about 2 feet since placing the crates, it may be supposed that they have contributed to produce this result, but one of the oldest pilots holds that the change is due to storms, and would have taken place without any works.

He states that the head of Mustang Island must first be protected against erosion by a riprap or groins, and further makes a project for excavating and revetting a canal or channel from Turtle Cove into Corpus Christi Bay, which would serve not only as a passage for vessels, but would, by its discharge into Aransas Bay, serve to arrest the erosion above Turtle Cove, due to the ebb waters of Aransas Bay, by deflecting these currents. He thinks—

The cost of building a jetty from Mustang or Saint Joseph's Island toward the bar, which would be able to resist the action of the storms upon the quicksand foundation, must be an insurmountable objection to any such experiment. The stone to be obtained at Rockport is too poor in quality for use in so exposed a work.

Captain Howell, in forwarding this report of Lieutenant Woodruff, says:

I coincide with Lieutenant Woodruff in the opinion that all the plans suggested and discussed by him offer no certainty of producing good results, and that the expense which would be incurred by testing them will be out of all proportion to the benefits derivable from success.

Capt. George B. McClellan, reporting to Bvt. Brig. Gen. Joseph G. Totten, Chief Engineer, U. S. A. (Ex. Doc., vol. 2, 1853–'54, p. 561), writes:

The passes at * * * Corpus Christi and Aransas have each but a single outlet, all exceedingly narrow, and none admitting any further decrease in width. The only possible application of dikes in these cases would be to prolong the walls of the outlet until they reached a point very near the present position of the bar, in order to concentrate upon one spot the whole action of whatever outward current there might be.

The ultimate effect of this would undoubtedly be the formation of a new bar outside; that, too, at no distant period. The immediate effect would by no means be certainly favorable, and the new outlet would be liable to be closed up by heavy storms (subject to breaking out again), as is now frequently the case with small inlets on the coast of Florida.

Capt. C. W. Howell, February 1, 1879, reports upon a survey in 1878 of Aransas Pass, Corpus Christi Pass, &c., and recommends the closure, to height of mean low-water, of Corpus Christi Pass, with the object, among others, of improving the channel between Corpus Christi and Aransas bays; dredging and deepening this channel; the construction of a jetty from the end of Saint Joseph's Island toward the bar; protection of the end of Mustang Island; preventing, by planting trees, the lower end of Saint Joseph's Island from losing sand by wind-drifts, and dredging channel to Rockport.

ESTIMATE.

Deepening channel over bar by jetty	$60,405 00
Protection of head of Mustang Island	126,440 00
Dam across Corpus Christi Pass	11,748 00
Planting south end of Saint Joseph's Island	2,000 00
Dredging channel between Aransas and Corpus Christi bays, three estimates	31,123 40 167,222 00 198,888 75
Dredging channel to Rockport in Aransas Pass	30,555 50
Total	628,382 65

The passes Cavallo, Arnasas, and Corpus Christi, while keeping a nearly north and south direction as long as sheltered by the sand islands and peninsula between them and the Gulf, on making connection with the Gulf turn sharply to the southeastward, so that the channels across their Gulf bars are nearly in the general or prevailing direction of the on-shore winds and storms. At Aransas Pass the chart also shows that the channel of the bar, as soon as it comes under the influence of the drift along the coast, turns again from a southeasterly direction to one more southerly.

In the communication, dated December 30, 1878, by Mr. H. C. Collins, assistant engineer, and filed with Captain Howell's report, many notes occur connected with the physical features of Corpus Christi and Aransas bays, which are herewith transmitted in substance.

The channel connecting these bays is partly an old bayou and partly dredged, under the control of a stock company, who charge tolls upon articles of freight carried through it. Its depth at summer low-tides is 8 feet, which has not decreased more than half a foot since it was cut through; it is very narrow at some points, though for most of the distance it is from 80 to 100 feet wide. The banks of the dredged portion, where thrown up above water in Corpus Christi Bay, are of blue clay, quite hard, and do not wash. No sand bottom was found in this portion of Corpus Christi Bay, but the bottom in Aransas Bay, from the head of the bay down to Lydia Ann and Ship channels, is sand. The whole shoal at the lower end of Aransas Bay is sandy in places, but the deep portions of this and Corpus Christi bays has a blue-clay bottom, except the shell reefs which run out from the shore in many places.

In Aransas Harbor the bottom blue clay is found at a depth of 27½ feet, and outside of the bar at 30 feet.

Of the two channels connecting Aransas Bay with lower harbor, that of Lydia Ann follows Harbor Island, and is over 10 feet for nearly its entire length, but has a bar at its upper end of 7½ feet, while the Ship Chan-

nel has 8 feet for more than half its length. The Lydia Ann Channel is increasing in width and depth.

The bad practice of cattle-grazing upon the coast islands and peninsulas has the effect of depriving the sand hills of their protective covering of grass, and these are being fast carried inland under the action of winds. This drift sand has an important bearing, not only upon the depth of some of the interior channels, but also of the pass, including the bar channels.

A great similiarity exists between Aransas and Corpus Christi passes, but the latter has cut its way for a distance of 8 miles from its head, while the former has only advanced 3 or 4 miles from a similar connection with its bay. Corpus Christi Pass is very shoal and narrow, and it has at its head less than 3 feet of water over a wide quicksand bar. The sand blown from the south end of Mustang Island was, at the time of the survey, much greater in quantity than that from Saint Joseph's Island. Corpus Christi Pass is said to have decreased to about half the size it had in 1846. It is now much shoaler and more narrow than it was at the time of Lieutenant Woodruff's survey in 1871.

The head of Mustang Island is continually receding towards the southwest, and Aransas Pass follows with it. A comparison of the Coast Survey charts of 1858 and 1868 with each other, and with Lieutenant Woodruff's of 1871, and the last survey of 1878, shows an annual rate of wear from 210 to 260 feet.

The area of these back bays is very great, and for nine or ten months in the year no fresh water runs into them. The evaporation is so great that salt is found in the shoal water far back from the gulf. From Laguna Madre, which is a part of Corpus Christi Bay, the beef-packers obtain their salt. In consequence of the evaporation, the bay waters are more dense than those of the Gulf.

From observations of the tides at Aransas Pass, the Gulf waters breaking, even on quiet days, upon the flat between Saint Joseph's Island and the wreck of the St. Mary, were carried in, during the flood, gray with sand, which was deposited by the time the current reached the light-house. The flood-tide currents were found only from the surface to about mid-depth of the passes for the rest of the depth, there being no current. The Gulf water remained entirely distinct from the bay water up through Lydia Ann and Ship channels, slowly mixing with the heavier bay water.

On the ebb, the current in the channel abreast the head of Mustang Island was about as strong near the bottom as at the top; and the notes of the survey also state that none of the water ran out over the flat where it came in.

It is also stated that in 1869 a short pier, 600 feet long, was run out from the south end of Saint Joseph's Island, with the aid of funds derived from private subscription.

The consequence was that for several months an increased depth over the bar of 2 feet was obtained.

Thus far, from the notes of the survey, which in some places have been literally transcribed.

PROJECT FOR ARANSAS AND CORPUS CHRISTI BAYS.

The problems then presented to the Board are:

First. The improvement of the depth of Aransas Bar.

Second. To improve the interior navigation from Aransas Pass up to Rockport.

Third. To improve the present channel connecting Corpus Christi and Aransas bays.

Fourth. As connected with the preceding, and to improve the channel into Laguna Madre, to close the inlet of Corpus Christi Bay.

Taking up these in the order named, the Board presents a project (see sketch below) of parallel jetties from the south end of Saint Joseph's Island and the north end of Mustang Island, contracting the width of water-way, and carried out to a sufficient distance to afford a draught of 12 feet at mean low-water over the bar, and of groins for the protection of the head of Mustang Island up to and beyond Turtle Cove, in conjunction with a beach flooring of mattresses, which may at certain points be necessary until the shore-line shall have been fixed and consolidated by the groins.

ESTIMATE.

North jetty:		
4,000 feet, 6 feet high, 7½ feet wide on top, at $36	$144,000	
1,000 feet, 8 feet high, 10 feet wide on top, at $58	58,000	
2,000 feet, 8 feet high, 20 feet wide on top, at $71	142,000	
		$344,000
South jetty:		
1,100 feet on shore, at $3	3,300	
900 feet, 6 feet high, 7½ feet wide on top, at $36	32,400	
2,800 feet, 8 feet high, 10 feet wide on top, at $58	162,000	
1,350 feet, 8 feet high, 20 feet wide on top, at $71	95,850	
		293,950
Groins:		
2,600 feet, at $4	10,400	
2,000 feet, at $8	16,000	
		26,400
Shore protection with mattresses:		
2,000 feet, 150 feet wide, at $12		24,000
		688,350
Contingencies, &c., 10 per cent		68,835
Total for jetties, groins, and shore protection		757,185
Planting trees on Saint Joseph's Island		2,000
Total		759,185

The portions of the project in full lines are recommended to be first constructed; and these, as well as the other portions designed for a later construction, should be undertaken in such combinations as to meet the necessities of the case.

One important consideration also ought to be to take the works in that order which would involve the least loss in the event of a long omission by Congress to appropriate further amounts.

One of the members, General Newton, considers it preferable to dispense with the jetty from Saint Joseph's Island, retaining that from Mustang Island, for several reasons. As none of the members consider that improvement of the bar would *necessarily* be permanent, because a mere extension of the pass by jetties may induce the closing of the channel as at Corpus Christi Bay, so by the consolidation of the drift sand about the jetties on both sides of the channel the impediments to the water flowing in and out may be further increased, and the closing of the pass, if such tendency now exists, accelerated. Second. Because one jetty on the south side of the pass may suffice, in conjunction with the north shoal, to sustain the ebb currents. Third. A wider opening will be left for the flood-tide. Fourth. One jetty would be less costly than two; and, Fifth. The other jetty, if further experience should indicate any beneficial effects to be derived from it, could be afterwards constructed.

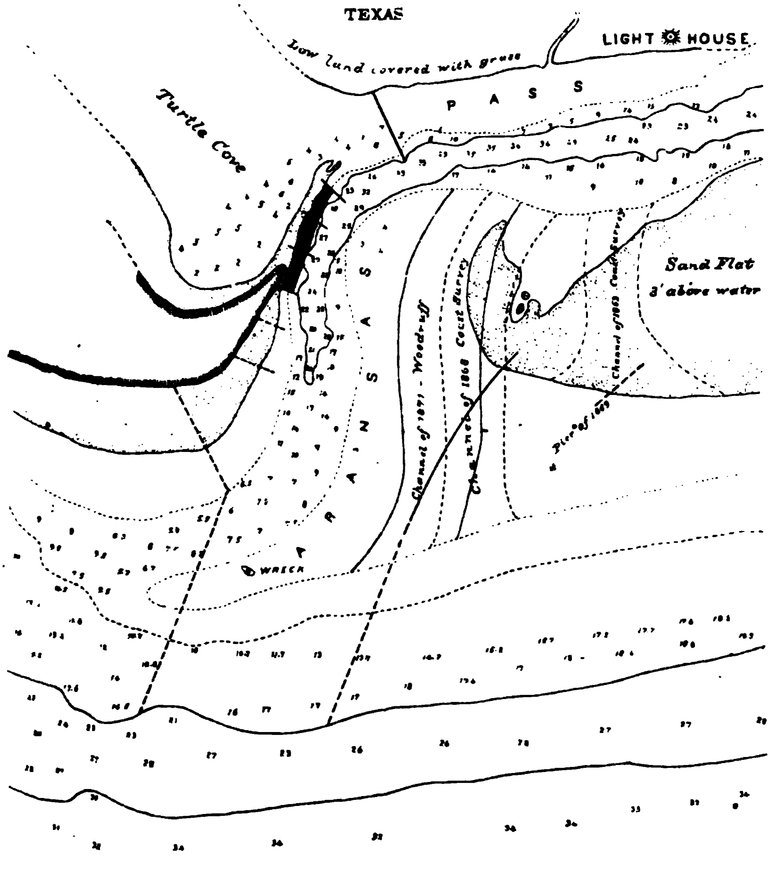
SHEET No 1

CHART

showing approximate location of works proposed for the improvement OF

ARANSAS PASS

TEXAS



ENTRANCE TO ARANSAS PASS

Scale

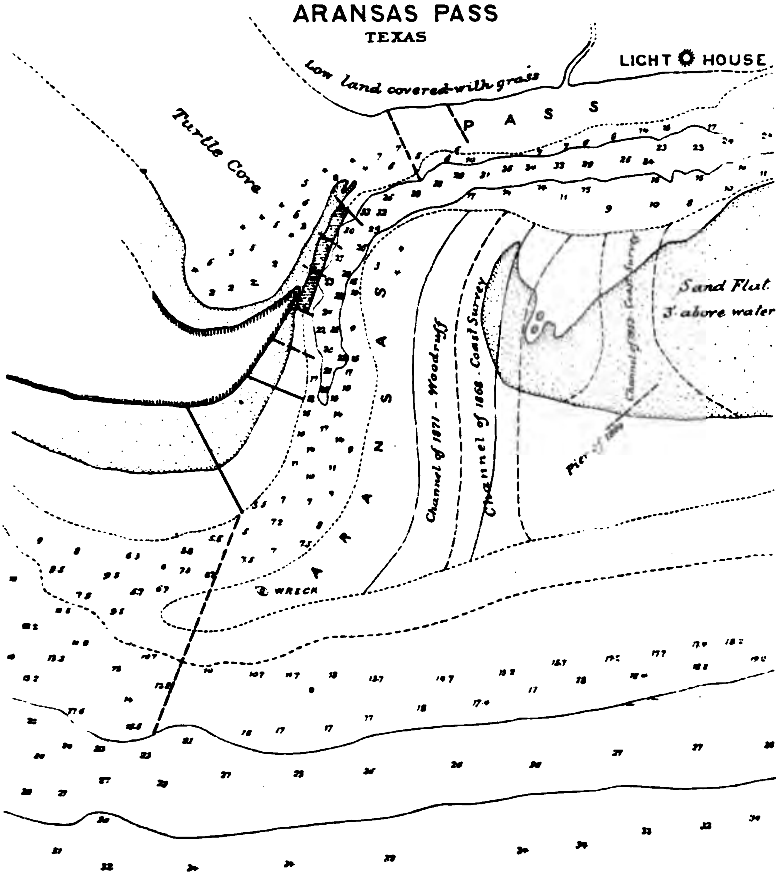
SHEET No. 2.

CHART

showing approximate location of works proposed for the improvement OF

ARANSAS PASS

TEXAS



ENTRANCE TO ARANSAS PASS

Scale $\frac{1}{20\,000}$

ESTIMATE.

South jetty:		
1,100 feet on shore, at $3	$33,000	
900 feet, 6 feet high, 7½ feet wide on top, at $36	32,400	
2,800 feet, 8 feet high, 20 feet wide on top, at $58	162,400	
1,350 feet, 10 feet high, 20 feet wide on top, at $94	126,000	
		$325,000
Groins:		
3,100 feet, at $4	12,400	
2,000 feet, at $8	16,000	
900 feet, at $16	14,400	
		42,800
Shore protection with mattresses:		
2,000 feet, 150 feet wide, at $12		24,000
		391,800
10 per cent. for contingencies		39,180
		430,980
Planting trees on Saint Joseph's Island		2,000
Total		432,980

The portions of this project in full lines are recommended to be first constructed, the probable effect being to stop the abrasion of the outer point of the island head as well as to produce an immediate effect upon the bar. The amount of funds available will not suffice for the section of jetty under consideration as well as for the first given, the construction of which should proceed together in order to protect the outer point of the island, but the construction of sufficient length of the jetty to produce an immediate effect upon the bar is possible with the funds on hand.

For future operations the protection of the head of Mustang Island and the prolongation of the jetty should go together, depending upon the necessities of the case, and adhering to the principles laid down.

The Board finds that no precedents have been established upon this coast competent to indicate the best mode of constructing the jetties and groins in those positions exposed to heavy seas. As the most suitable in respect to economy and convenience, they suggest a structure of reed mattresses, supposed to be proof against the teredo, weighted with small stone, the upper and exposed surfaces to be paved with large stone or concrete blocks. Brush might advantageously be placed between the mattresses, in the interior of the mass, where it would be protected from the worm. The Board also recommends that the works in places exposed to the full force of the Gulf storms should be carried on during the favorable seasons of the year, and that the sections successively commenced should be entirely finished and protected before the advent of the stormy seasons. As to those portions of the project with little or no exposure to the waves, much cheaper constructions, suggested by the materials at hand, would suffice.

Before discussing any project for providing a depth of 20 feet upon the bar in order to constitute the lower part of Aransas Bay a harbor of refuge, or as a resort for lines of large steamers, the Board considers it best to await the results of the experience to be gained as to feasibility and cost from their more moderate project.

As to the second problem, viz, the improvement of the interior navigation from Aransas Pass to Rockport, the discussion of this should wait upon the protection of Saint Joseph's Island from abrasion by winds and upon the success of increasing the depth over the bar to 12 feet. The depth of water in this interior channel is now 8 feet, and if

dredged before the protection of the island, would be liable to deterioration from sand blown off by winds. The third problem—the advisability of improving the channel between Corpus Christi and Aransas Bays—may likewise wait upon the improvement of the bar, before obtaining which result no additional depth would be necessary.

The fourth problem—the closure of Corpus Christi Inlet—should not be undertaken until its necessity becomes more apparent than it now is, or before the communication between the two bays is made wider and deeper.

The recommendation of Captain Howell, to plant trees upon Saint Joseph's Island for its protection against abrasion by winds, is indorsed.

It is stated that a pier 600 feet in length, constructed in 1869, from the end of Saint Joseph Island, caused the temporary deepening of Aransas bar. It is not clear how such effect could be attributed to the structure, unless, as Lieutenant Woodruff reports, it was instrumental in closing a swash channel then existing. Its effect in preventing the transportation of sand into the channel by the waves and flood currents should have been very slight, since Mr. Collins, assistant engineer, reports that the extent of shoal over which the waves and currents acted extended from the point of Saint Joseph's Island to the wreck of the Saint Mary, a distance of about 5,500 feet.

At the present time, however, no swash channel exists to the deterioration of the depth on the bar, and a much more considerable length of jetty would be required to produce any effect at all.

It is difficult to perceive how a sufficient length with such object could be constructed from the available funds (about $35,000, appropriated March 3, 1879) unless the works be made of a slight and temporary character, liable to destruction by the first severe storm.

The communications to the Secretary of War on the part of the Hon. Pryor Lee, president and general agent of the Aransas Road Company, bearing date June 16 and 17, 1879, with printed summary statement by the road company on application to the Texas legislature for relief, and the act of relief granted, all go to prove that the Aransas Road Company possesses no right to collect tolls on vessels entering Aransas Pass.

GALVESTON HARBOR.

An examination of this harbor with a view to the question of its improvement was made by Lieut. Geo. B. McClellan, Corps of Engineers, in the year 1852, but it does not appear that anything resulted therefrom.

In 1867 a survey of the harbor was made by Lieutenant Stanton, under direction of Major McAlester, Corps of Engineers, and reports were submitted, with estimates, looking to the improvement of the inner harbor, and an appropriation was made in 1868 to dredge the inner bar.

In the year 1869 the citizens of Galveston commenced a pile dike, which was extended from the city towards Fort Point, with a view to contracting the water-way, and thus scouring off the inner bar. About 1 mile of this dike had been completed in 1873 with beneficial results.

Captain Howell, Corps of Engineers, assumed charge of this harbor in 1869, and after a short study of the position, gave it as his opinion that dredging would furnish but a temporary relief. New surveys were therefore instituted by him, and after their completion and a thorough investigation of the subject involved, a project was submitted to the Chief of Engineers in 1873 for the removal of the inner bar and deepening the channel over the outer, possibly to 18 feet depth.

This project consisted in the extension of the city's dike to the northeast, to force the water flowing from Galveston Harbor in that direction far enough to remove by scouring the inner bar before permitting it to flow toward and into the Gulf.

2d. In the prolongation of this dike after turning it seaward well out toward the outer bar.

3d. In the construction of a similar dike from the outer shore of Bolivar Point in a direction nearly at right angles to the coast line and approximately parallel to the first; both jetties to be extended to such distances as would, by contracting the water-way, deepen the Gulf bar to a possible draught of 18 feet.

The Board of Engineer officers (three of whom, including Captain Howell, are members of this Board) ordered, February 2, 1874, to consider and report upon the foregoing project, approved the general plan of the improvement, but expressed their doubts as to the durability of the cemented gabions with which it was proposed to build the jetties.

The report of the Board will be found in the Report of the Chief of Engineers for 1874, Part I, page 736. After a short description of the position and its tidal phenomena, the Board give their opinion of the improvement as follows:

That, if piers proposed by Captain Howell were constructed, extending over the bar, the depth of water thereon would be increased in an important degree, though exactly what depth might be looked for cannot be predicted. It is also believed that the inshore extremity of the pier on the Fort Point side of the entrance, from the point where it connects with the bulkhead constructed by the city to where it joins the long, straight portion running to the bar, will have the effect of moving the bar at the Galveston Harbor entrance near to Bolivar Channel, whereby it will, to some extent, be carried off by the main current of the latter.

As to its permanency, and method of construction with gabions, they added:

If taken literally, this condition (of permanency) cannot, in the opinion of the Board, be fulfilled by the present project, nor by any other known method of improvement. Though the present piers will not secure an actual *permanency* of the depth at first attained, unless they should be from time to time extended, * * * it is believed that the requirements of a practical permanency will, under the conditions before expressed, be fulfilled.

As regards the method of construction proposed by Captain Howell the Board is compelled to speak with less confidence. The importance of some device for piers or training-walls for the improvement of our harbors which shall be less costly than those hitherto practiced, is readily recognized * * *

The Board therefore thinks it would be well to make a trial of the device, and would thereforere commend that be tested by first constructing the inner end of the pier on the Fort Point side, and if found to succeed there, that the pier on the other side be commenced at its shore end, while at the same time a length of, say, from 300 to 500 feet be put down near the bar extremity of the same pier to test its efficiency in the most exposed position, the extremities of this detached portion being protected from the undermining action of the waves and currents by a suitable apron of bags of concrete or other material. By carrying out the shore end of the pier at the same time as or before the experimental portion on the outer bar, some idea can be formed as to the width to be given to the latter to enable it to withstand the violent action in that exposed position.

It was thought by Captain Howell and the other members of the Board that the drift sand would bury the gabionnade, and the trial prescribed was therefore needed to test its durability until thus covered.

An appropriation of $60,000 for the improvement of Galveston Harbor was made in 1874 and the work commenced. During the summer nearly 200 running feet of gabions were laid in the Fort Point dike or pier, which withstood the September gale. In consequence a favorable report thereon was made to the Chief of Engineers, who referred the question as to the method of construction back to the Board by letter of instruc-

tions of December 31, 1874, to decide if the test to which it had been subjected was in their opinion adequate to establish the system.

The reply of the Board, given in Report of the Chief of Engineers, Part I, 1875, page 869, says briefly:

We do not, therefore, regard the trial made by Lieutenant Quinn as decisive, but still advise that the full tests recommended in our report of January 1874, be carried out.

Should further trial prove it a suitable structure for a breakwater on the Gulf, its manner of construction, whether with a single row of gabions, or two, or even three in the first tier, and its height and finish at top, must be worked out by continued experiment. So great a saving will be effected by limiting the construction to a single row of gabions in each tier, that the trial with this limit ought to be made in connection with the method of two rows in those portions of the jetties it is proposed to build in order to test the practicability of the system.

In the summer of 1875, with the further appropriation of $150,000, preparations were made for continuing the work on a larger scale by increasing the plant, collecting a sufficient supply of material, and constructing a large number of gabions. In addition about 2,000 feet of gabionnade had been put in place when the hurricane of September 15, almost unprecedented in duration and force, destroyed nearly everything on hand and washed away the north part of Galveston Island in the vicinity of Fort Point to such an extent as to leave portions of it under water at ordinary high-tide. The losses to the government work by the storm were reported as amounting to $50,000.

In consequence of reported changes in the channels and shoals of the harbor of Galveston and its entrance, produced by the hurricane of September 15, 1875, the Board upon the improvement of this harbor was again called upon, December 10, 1875, to review the subject and to give their opinion whether any modification of the plan heretofore followed was made necessary by the experience due to the gale. Their report is given in the Chief of Engineers' Report of 1876, part I, page 581, from which we quote their conclusions, as follows:

1. That the two jetties or training walls recommended in the report of January, 1874, will, if constructed, produce an important increase of depth over the outer bar.

2. That the portion to be first constructed should be that part of the west jetty starting from Fort Point towards the main channel and continuing as far along the same as may be necessary in order to improve the inner bar, by preventing the transport of the sand by waves and currents into the inner channel and allowing the currents of that channel to increase the erosion.

3. As the use of gabions is a novelty, and consequently as we have no experimental knowledge regarding their reliability for such works, they should not be adopted definitely for the main works until a more thorough and extended test shall have been made of them by the extension of the inshore end of the Fort Point jetty, by constructing from 300 to 400 feet of the northern jetty on the most exposed position on the bar and of a portion of the inshore end of that jetty, as recommended in our first report.

It should be stated that, in the opinion of the Board, the use of these gabions in exposed positions can be attended with success only in case they shall be soon covered by the drifting sands, so as to protect them from injury from the continued action of waves, from the shock of floating bodies, and from all other causes which might tend to disrupt them and allow their sand filling to escape. When so protected they will form a nucleus for the sand ridges as stable and as permanent as if of stone or concrete. But if not so protected, those gabion structures will be constantly liable to injury and in time to decay, when, losing their sand filling, the structure would soon be washed away. That the proposed jetties will be so covered seems probable, but can be determined only by trial such as we have recommended.

Establishing a suitable plant on Bolivar Peninsula, instead of rebuilding it at Fort Point, collecting needed material and manufacturing gabions with which to resume construction, nearly exhausted the balance of the second appropriation and caused cessation of work early in July 1876. The third appropriation ($142,000) was made in August, 1876 but was not freely available until February 22, 1877. With it the Bol-

ivar pier was commenced and the Fort Point gabionnade, designed to remove the inner bar, continued and finally completed, the funds giving out in November of that year. In June, 1878, a fourth appropriation ($125,000) was made by Congress, which has been expended in the construction of the Bolivar pier to a length of about 7,000 feet, and the collection of material and manufacture of a large number of gabions for this summer's work.

The inner bar by the action of the Fort Point pier has been removed to a depth of 20 feet. The effect of the Bolivar pier is reported as favorable, but it has not yet been extended far enough to give an increase of depth on the outer bar.

Having thus given a brief history of the works of improvement at Galveston during the past five years, the Board proceeds to the main question presented for its consideration, viz: Have the cemented gabions used thus far in building the Galveston piers been sufficiently tested as to solidity and durability to warrant their continued use in the completion of these piers?

In their trial at the Fort Point pier they stood against the force of currents and storm waves until they were covered by sand, thus fulfilling the purpose for which they were intended by becoming the nucleus for a sand pier. It was the expectation of Captain Howell, the originator of this method of construction, as well as of the Board that recommended its trial, that the drift sand of the coast would cover the gabionnade in a few months after it had been placed in position, or at least sufficiently so to protect it in great part from the destructive effects of storm waves. While such result was obtained at the Fort Point pier, the same success has not attended the construction of the Bolivar pier. This latter has been extended seaward into the open gulf about 7,000 feet. A portion of the gabions were placed directly on the sand bottom. These settled into the sand to depths varying from $\frac{1}{2}$ to $\frac{2}{3}$ of their height, possibly by oscillation, while those placed on mattresses do not appear to have sunk to any appreciable degree; nor has the drift formed against them thus far, as was anticipated. Exposed to the full force of the storms, about $\frac{1}{7}$ part of the gabions placed in the north pier have been broken up and disappeared. Captain Howell attributes this loss in part to the fact that many of these gabions had been kept on hand for a long period, between one and two years, before they were used, and that in consequence the wood of which they were in part made had suffered partial decay. Further, that many of the gabions thus lost were not entirely filled with sand and did not attain their full weight, stability, and strength. Many delays and adverse circumstances have attended this work as thus far carried on.

It is not inappropriate here to allude to the magnitude of this enterprise. The building of 7 miles of piers into the open Gulf of Mexico, beyond the shore line, is an undertaking of its kind unprecedented in this country. The Delaware breakwater and those more noted abroad, as at Plymouth, Cherbourg, Algiers, and Port Said, being enrockments of natural or artificial stone, are not parallel cases. They were regarded as too expensive methods of construction for this locality. The question at Galveston was to build into the Gulf (where the water is shoal enough to become in violent storms either a continuous line of breakers or sufficiently approaching thereto to involve the destructive effects of wave translation) two piers by some method that would bring the cost within justifiable and therefore practicable limits of expenditure. It was with this view that the cemented gabion was resorted to. It was an experiment under peculiar circumstances. It finds only in part a

parallel in the improvement of the mouth of the Maas, the outflow of which was in part tidal and in part a river current, and the piers a departure from the heretofore-established system known as enrockment. It is quite probable that the same system, viz, alternate layers of mattress and stone, carefully laid and protected on the slopes and top curved surface above water by large blocks selected and placed with care, might have been efficient at the Galveston piers; but it was thought to be too costly on account of the difficulty of obtaining suitable stone. The gabion, therefore, was resorted to as worth the trial, and with the hope that it would furnish a method of construction in like cases not so expensive as to be prohibitory. As an experiment, it was open to modification when experience should suggest changes promising improvement. The change from the cylindrical to the large oblong gabions was made soon after the Fort Point gabionnade was commenced with a view to greater weight, and hence to stability and to economy of construction; but it is questionable if the change has not weakened the structure. This was of no consequence in the south pier, or so long as the gabionnade was rapidly covered by drift sand; but in the north pier, which has thus far shown very little collection of sand, the strength of the gabion, and hence its durability, becomes an essential feature. The fact that one-sixth part of those laid on the north pier have been destroyed is proof that they were not strong enough to withstand the waves to which they were subjected. Defects in the making, the material, and the filling may account for the breaking of a part, perhaps the larger part, of these lost gabions, yet the inference remains that they are not strong enough, as laid, to undergo continued battering of the waves. In this connection it should be stated that the loss occurred on the inshore portion of the gabionnade, where they were subjected to greater strains by the force of the shoaler water translated into breakers by storms.

It would, however, be very unjust to the originator of this system of construction to condemn it on imperfect evidence without personal examination and without being sure that we comprehend fully all the circumstances under which an apparent or partial failure at one point has occurred. Had any other system whatever been used, it is quite probable there would have been delays, destruction of plant, and other losses, as well as occasional injury to the unfinished work by reason of the violent storms of this locality, and the frequent cessation of work from that and other causes.

It seems quite probable that the gabions have not been made as strong as they should be; that they are not sufficiently braced inside, and that the heads are not as secure as they might be made by being tied together by several rods. The question also occurs as to the best manner of placing them, whether in a single row, lengthwise, or in two rows, side by side, or removed a short distance one from the other; or again, in a single row placed crosswise.

Until the above methods have been tried with gabions made stronger than those hitherto used, the Board cannot regard the question of their success or failure as fully decided.

It may yet occur that the gabionnade will collect drift-sand, and thus protect itself. The time that has elapsed since the Bolivar pier was commenced is not sufficient to determine that question.

This Board, therefore, in conclusion, recommend, as Captain Howell has on hand about 600 gabions (which if not used would be mere waste) that he strengthen them and try the methods of placing them suggested, and cause close observations to be made with a view to determine (if

any fail), in what way they are injured or give way, and to gather such other experience therefrom as will enable this Board to form a decision as to the efficiency of the system after this further trial. In the mean time no more gabions should be made.

This Board further suggests that the method by alternate layers of simple brush or reed mattresses and stone be tried, provided stone can be obtained from the Trinity or San Jacinto rivers above, or from any other source, more cheaply than concrete can be made. If not, that concrete in blocks be used, or in bags, instead of stone. The object of trying this method is twofold—

1st. To determine, if possible, upon some method of surface finish that will endure without displacement the shock of the storm waves.

2d. To determine its cost or relative economy to other systems.

There can be little doubt that the Dutch system would be as successful at Galveston as at the mouth of the Maas.

Any system, however, that exposes small stone on the surface and slopes to the action of open-sea breakers will be liable to injury, and will at times require repairs. Breakwaters which are enrockments have usually been covered on the upper part of their sloping sides and on the top by very large selected stone placed with care, and they have been further protected by a heavy course of stone laid as a binding wall on the upper surface, or they have been built of blocks of concrete of a weight of 25 tons and upwards, large enough to resist the moving power of waves. The outer portion of the two jetties built into the Gulf of Mexico, at the mouth of the South Pass of the Mississippi, have been injured by storm waves, which rolled the top stones—quite large granite blocks—from the surface down the slopes into the sea. While, therefore, we recommend for trial the system by alternate layers of mattresses and stone, we suggest that the Holland or Maas dike be taken as the model, the mattresses of which are made thin and sufficiently weighted with small stone to consolidate them as the work progresses. There is, however, no necessity for the use of fascines, for reed or brush will consolidate sufficiently if the mattresses are made thin and properly loaded. The protection of the surface is the difficult question to be solved, and we are not aware of any method to accomplish that object with an absolute surety. The pavement of the slopes and upper surface, after the Dutch method, is better tested than any other. It is quite possible that concrete blocks of great weight may prove to be a good finish to these jetties as large stone have been to the ordinary stone breakwater.

There is no very cheap way of building jetties into the ocean. As far as we can learn, the Maas jetty, where 16 feet deep, cost about $200 per running foot. At Galveston the depth will vary from 8 to 12 feet, and the cross-section will be very much reduced, varying nearly as the squares of the depths. Could suitable stone be procured, the cost might not be relatively greater than in Holland. The system is worth the trial, omitting the construction of fascines and adopting instead the simple mattress, made of layers of brush or reeds placed at right angles to each other.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen.
JOHN NEWTON,
Colonel of Engineers, Brt. Maj. Gen.
Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, Brt. Maj. Gen.

N 9.

IMPROVEMENT OF HARBOR AT BRAZOS SANTIAGO, TEXAS.

The only survey (in so far as official records show) of this harbor and pass was made in 1871, January 28 to March 13; and report, submitting plan and estimates for improvement, was rendered April 7, 1871.

FROM REPORT OF THE SURVEY.

1. The harbor is situated about 10 miles from the mouth of the Rio Grande.
2. The depth of water on the bar at the mouth of the river was 4 feet, making it necessary to "lighter" everything destined for Brownsville.
3. The *bar* in the usual curved form, obstructs the harbor directly across the mouth of the pass, and is so situated as to be entirely exposed to heavy storms; it is composed of a quicksand formation, acted upon with extraordinary facility by water. The channel across the bar constantly shifts. The depth of water (in 1871) was 7 feet at high tide.
4. Greatest depth of water in harbor 27 feet.
5. The improvement desired is a deeper channel across bar.
6. The harbor is ample for the commerce of the port and needs no protection.
7. The only possible application of dikes (jetties) here would be to prolong the walls of the outlet until they reach a point very near the position of bar, in order to concentrate upon one spot the whole action of whatever current there might be. The immediate effect of this might be favorable. The ultimate effect would be the formation of a new bar outside the present one, and that at no distant period.
8. The formation of structure being in quicksand, difficulties of construction would be very great.
9. The estimate (following) proposes a single concrete jetty (3,500 feet in length) with an average cross-section 22 feet in width by 15* feet in height, the width being at every point 50 per cent. greater than the height. The head of jetty to be circular, and 50 feet in diameter.

ESTIMATES.

1,752 palmetto piles, 25 feet each	$13,140 00
148,197 feet, board measure, 8 by 8 inch cap-timber, &c	7,409 85
13,961 pounds 1 by 18 inch bolts	1,675 32
Framing ties, &c	1,314 00
Driving piles	3,504 00
30,610 gunny sacks	6,122 00
49,431 cubic yards concrete	741,465 00
Total cost of jetty	774,630 17

If after constructing a jetty of this kind, it is found that the bar has only moved farther out into the gulf, which will probably be the case, it will then be necessary to prolong the jetty to the new position of the bar.

The object of submitting this estimate is to show the cost of what is believed to be the best plan for improvement. The necessities of the case do not seem to call for such an expenditure.

* * * * * * *

From the date of report of survey as above given, until 1878, nothing appears to have been done in regard to this harbor.

In 1878—November 29 to December 30—the obstruction occasioned

* Settlement of 4 feet allowed.

by the wreck of the bark Rene des Mers was removed from the harbor; appropriation of $6,000 by act of Congress approved June 18, 1878.

PROGRESS MADE DURING YEAR ENDING JUNE 30, 1880.

No funds available for expenditure on this work during the year.

The first appropriation for improvement proper (the amount given in 1878 being for the removal of obstructions to navigation) at this point is by the terms of the act of Congress of June 14, 1880, viz, $25,000.

In any plan suggested for the improvement of the harbor at Brazos Santiago, the sum available, $25,000 will not warrant actual commencement on the work.

It is therefore recommended that the appropriation of $25,000 be held to await further action of Congress, and in the mean while measures may be taken in hand to project a defined plan for the expenditure of appropriations to follow hereafter.

The work is located in the collection district of Brownsville, Tex., and the nearest light Brazos Island light (beacon).

Money statement.

Amount appropriated by act approved June 14, 1880	$25,000 00
July 1, 1880, amount available	25,000 00
Amount* (estimated) required for completion of existing project	774,630 00

N 10.

PROTECTION OF RIVER BANK AT FORT BROWN, TEXAS, FROM ENCROACHMENTS OF THE RIO GRANDE.

Original appropriation (act of July 31, 1876)	$10,000
Appropriation of March 3, 1879	7,000
Total	17,000

In 1871 private parties built a pile-jetty about 330 yards upstream from the garrison wall, the greater portion of which was washed away in years since.

In April and June, 1877, there was constructed a pile-jetty (or breakwater); the axis of the main work was a line starting at the river bank at the foot of Fourteenth street, Brownsville, and made an angle of 9° with the general direction of the shore line from the starting point to a point in front of the Administration Building.

The main work was 150 feet long, and was connected with the bank below by a wing built in the same manner as the main structure, and making with it an angle of about 130°, the object of the wing being to prevent the formation of a dangerous eddy below the work.

In March, April, and May, 1878, repairs were put upon this pile-jetty; and, also, from the 6th pile of the main work was commenced a new structure, upon the same plan, continuing about 130 feet further up the stream, the last 40 feet of this distance being sheet-piling. About this same time of the year the Levee Company of Brownsville put in a small jetty of live-willow piles just above the city, at an expense of about $3,000.

* Estimate for one jetty, on south side, made in 1871.

Cost of original structure and wing, $7,197.50; therefore Captain Gregory, in charge then, recommended the appropriation of $14,400, to build 400 feet of extension.

I was directed by Special Orders, No. 30, dated Headquarters Corps of Engineers, March 10, 1880, to relieve Capt. W. R. Livermore of the charge of this work.

Under instructions, Captain Livermore submitted to your office a project for the work, dated Fort Brown, Tex., February 27, 1880. This was referred to me by indorsement for consideration in connection with the preparation of my project for the application of $7,000 made by the river and harbor act of March 3, 1879, "for protection of river bank at Fort Brown, Tex.," assigned to him (Capt. W. R. Livermore) by paragraph 3 of General Orders, No. 30, headquarters Corps of Engineers, current series.

In accordance therewith I wrote your office on the 24th of March:

> Captain Livermore's project of lining the river bank with a mattress of brush to prevent further erosion seems to be the correct method of procedure, and is what I would recommend be done with the available funds.

Upon your receipt of this I was advised by telegraph that the project was approved, and I was directed to execute it.

Taking the first steamer for Brownsville, I arrived there the night of the 11th of April. The morning of the 14th a gang of 10 men began cutting brush on the reservation, and by the evening of the 22d we had placed in position on the river bank 2 mattresses, measuring 65 by 32½ feet, thus covering about 70 running feet of bank; the river was at its low stage, and about 35 feet of the mattresses were under water, lying upon the bed of the river, well anchored down by ballast consisting of bags of brickbats, there being no stone available.

Leaving the work in good and well-instructed hands I returned to Galveston. By the close of the month six mattresses (65 by 32½ feet) were successfully placed, covering about 200 running feet of bank. By the 27th of the month, we had exhausted the supply of brush in the reservation and began cutting it at points on the river above and below.

After placing the third mattress the river suddenly rose 12 feet in one day, and the following day fell 9 feet; our incomplete work therefore received a severe test which it sustained unflinchingly and gave us the assurance that our work would be a success. As we anticipated, a large amount of sediment was deposited upon our mats, which insures its perfect stability.

Our work continued with little interruption during May and till the 11th of June, when it was brought to a close by reason of the scarcity of brush and for the further reason that we had completed the work originally contemplated; 1,047 running feet of bank had been covered with mattresses, measuring 68,000 square feet of surface, 100 running feet of bank below has been covered with trees and brush anchored with wire, and the old jetty (Captain Gregory's) filled in the same manner. Provision has been made for carrying the surface drainage away from the bank and into the lagoon, and a neat fence formed of our fascines horses gives material protection to the river bank and the road which runs along its crest by the Administration Building.

A brief description of our work may not be out of place here. Its simplicity and cheapness, and withal its undoubted efficiency, will recommend its adoption under similar conditions.

Here we had a bank on the concave side of the river, 14 feet high above the level of low-water, composed of strata of sand and clay, hugged by the current, which, even in a low stage of the river, has a

considerable velocity; the depth of water along this bend at low stage being over 20 feet.

Sudden rises of the water caused by melting snow in the mountains or by heavy rainfall occur each season, notably in June, when the river boils and surges in a terrific manner, and carries before it everything placed in the river in the form of a jetty or training wall; the bank is softened, and when the water falls it caves in and dissolves like sugar in hot coffee.

This action has been going on for years, and lately the danger of its cutting through (210 feet) into the lagoon has been quite imminent; should such an event occur, valuable government buildings would be swept away, and historic old Fort Brown with its site would most assuredly be taken by the Mexicans.

It was with a view to guard against such a contingency that the appropriation of $7,000 was made by Congress.

For the past ten years the Mexican point (Santa Cruz) opposite Brownsville has been gradually eaten away by the current of the river directed against it by jetties built by private parties for the purpose of reclaiming land for the city of Brownsville. The effect of this change on the river bed has been to direct the full force of the current against the government reservation below and adjacent to the city. Captain Gregory put in a jetty here in 1878 to direct the current from the bank. The point of impact of the current was constantly descending, and soon it struck the bank below and cut in behind the jetty to its serious injury and imperiled the Administration Building.

The bank now for over 1,000 feet below Captain Gregory's jetty is thought to be safe against further erosion in consequence of our brush mattress covering. Its mode of construction was as follows:

Abundance of excellent brush being at hand for the cutting, fascine ropes were made 4 to 6 inches in diameter and in lengths of 65 and 32½ feet, the longer for the circumstance of the case, the shorter for convenience. A raft was constructed and framed over with parallel rollers—dimensions of our raft (about 30 feet square) were limited by available material therefor—and moored against the bank, which had been previously roughly graded.

The longer fascine ropes were then run, end on, down the bank and out onto the raft, the upper end resting at the crest of the bank, the lower at the outer edge of the raft, and spaced about 3 feet apart; 11 fascines sufficed. The shorter fascine ropes were then rolled down the bank and spaced likewise 3 feet apart and at right angles to the former, the whole forming an open network of square meshes, with both ends of fascines extending all around, 1 foot beyond the last crossings.

Every crossing around the edge and every alternate crossing inside was then lashed with rope the size of a clothes-line, having an eye turned in one end, the other end being secured temporarily to the top of a stake placed vertically in the fascine so that it could be easily found after the filling brush and upper grillage had been placed, when it served to fasten the crossings to the top grillage and to securely bind the mattress compactly.

The other crossings of the grillage not already secured by rope, were bound with a smaller cord.

Upon the lower fascine ropes and between the cross ones, brush was laid, carefully distributed, so that when compacted it would be close and about 6 inches thick.

Over this were then placed the long fascines, directly over and corresponding to the ones below, between these was laid another compact

layer of brush 6 inches thick crossing the layer below, and above the shorter horizontal fascine ropes corresponding to the ones below, the crossings being marked by the stakes. The ropes about the stakes were then used to bind the crossings and formed a compact mattress 18 inches thick. The other crossings, as in the bottom grillage, were then bound with smaller cord, and stakes were then withdrawn.

The mattress was now complete, and being anchored at the crest of the bank, the raft was withdrawn from under it, when it floated till weighted by accumulation of sediment from the water or by ballast placed thereon. The raft was brought to position again and another mattress construced, and so the work proceeded till the whole river bank was covered.

Over all rubbish and dirt may be dumped, and grass, weeds, and brush be encouraged to grow, which ought soon to consolidate it and put it beyond chance of destruction by the elements.

During the progress of our work, the Mexicans placed a jetty on their side just above Santa Cruz point, extending well into the bed of the river, and as a result the current is thrown directly against the city of Brownsville, where it threatens to do great damage in spite of the efforts of citizens who are endeavoring to hold their own, by covering the low ground with a system of brush fences. The effect upon our work, however, is beneficial, as the current is now parallel to it.

As our work rests upon valuable city property, it is presumed it will be protected, and the river will not be permitted to get in behind it.

In conducting this work I have been ably seconded by Mr. S. W. Brooks, the superintendent in charge, to whose zeal and energy the speedy execution of the work is due. Anticipating the usual June rise of the river, time became an essential element.

My expectations have been more than realized, and to Mr. Brooks my acknowldgments are made.

Money statement.

July 1, 1879, amount available	$7,000 00
July 1, 1880, amount expended during fiscal year	5,704 86
July 1, 1880, amount available	1,295 14

APPENDIX O.

REMOVAL OF RAFT IN RED RIVER, AND CLOSING TONE'S BAYOU, LOUISIANA—IMPROVEMENT OF CYPRESS BAYOU, TEXAS; OF THE MOUTH OF RED RIVER, AND OF RED RIVER AND CERTAIN RIVERS IN MISSISSIPPI, ARKANSAS, AND TENNESSEE—PRESERVATION OF THE PORTS OF MEMPHIS, VICKSBURG, AND NATCHEZ—WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

REPORT OF MAJOR W. H. H. BENYAURD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 1, 1880.

GENERAL: I have the honor to transmit herewith annual reports upon the works under my charge for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 1.

REMOVING RAFT IN RED RIVER AND CLOSING TONE'S BAYOU, LOUISIANA

The above works are very different in their nature, and the localities at which operations are carried on are widely separated. While the appropriation for the whole is amply sufficient for the raft-work, it is insufficent for that and the closing of Tone's Bayou, and therefore I have never been able to carry on this latter work to the best advantage. I would respectfully suggest if new appropriations be made that these works be separated.

1. REMOVAL OF RAFT IN RED RIVER, LOUISIANA.

During the low-water season of 1879, the steamer Florence, belonging to the above work, not being needed therefor, was sent to Saint Louis for a general overhauling, after which she was sent into the Tallahatchee and Coldwater Rivers, Mississippi, for operations. In January last she was sent to Shreveport to be in readiness to remove and break up every jam that might occur in the river above.

Only one jam occurred during the first rise. This was broken up without difficulty, and uninterrupted navigation maintained until June,

when a rise from Upper Red brought down a great quantity of drift which lodged in the raft region.

The Florence being employed in towing the dredgeboat to the mouth of Red River, I obtained from the Red River Transportation Company the use of the Willard and Jo. Bryarly for the work of removing these jams.

The following work was done:

Jam No. 1 removed; it was about 15 miles above Shreveport, and about 1,800 feet long; No. 2, about 2 miles above was about same length; No. 3, 3 miles above was about ½ mile long; No. 4, 2 miles above, a small jam; No. 5, about 1 mile above Hurricane Bluff; this was a bad jam, caused entirely by some timber cribs belonging to Jones & Co., of Shreveport. This drift was so badly jammed that several cribs of logs were standing on their ends, and through the whole drift much of the timber was standing 10 feet above the surface of the water; the length of this jam was about 1½ miles, immense cottonwood trees lying in all directions. This was cut and passed down in small lots, but at Gold Point, about 12 or 15 miles below, the cribs caught again on some snags and formed another jam, while the Willard was above it. At this time the steamboat Brandon came down, and with her crew and that of the Willard, work was commenced at the lower end, cutting and pulling out with block and tackle. When about two-thirds through, the Bryarly came up and helped the work of removal.

It is probable that a great portion of the above-mentioned drift would have passed through the channel without blocking the same up, if it had not been for the fact that a number of cribs of large timber, intended, for Messrs. John R. Jones & Co., of Shreveport, were put into the river on the rise, and sent off without any person to look after them and see that they did not get caught by snags, &c., and so cause a jam. As many as 30 or 40 of these cribs are sent off at once, with only the last crib, called a driver, manned with 6 or 8 men. The parties in interest knew perfectly well that their timber must go through, for either the government or the steamboat men in the interest of navigation are bound to keep the river open. Attention is called to this point, with a view of seeing if there be a law which shall prevent the obstruction of the river in that manner.

2. CLOSING TONE'S BAYOU, LOUISIANA.

The work of closing Tone's Bayou was commenced in June last with working force under charge of Geo. R. Wilson, assistant engineer, and was continued until September, at which time the dam was 24 feet high and between banks 250 feet long. The allotment of the appropriation was not sufficient to carry it up to its whole height.

The top was covered by a heavy layer of stone to weight the mattresses down, and prevent the heavy drift timber which goes down the bayou on every flood, from knocking the top to pieces. This has been one serious drawback to the full completion of the dam. The amount appropriated each year has not been sufficient to carry the dam completely up to high-water mark as originally intended, consequently every high-water a portion of the top of the dam has been carried away. This had to be rebuilt the following season, only to be again destroyed the next. In addition I have had to keep a watchman on the work continuously, to see that the same be not cut and to prevent some of the people in that section of the country from carrying away the stone covering. Rock is quite a scarcity.

The low-water dam has been maintained, and it has been a source of great assistance to the navigation of the river below Shreveport. The water reached a point last year 3½ feet below the low-water of 1878, which up to that time had been the lowest ever known. Notwithstanding this, steamboats made regular trips from Shreveport to Grand Ecore, a thing never attempted before the partial closing of the bayou.

The amount of work done during the period above mentioned was as follows:

Cords of brush measured in place (this includes 1,406 cords made into mattresses)	2,291
Linear feet of poles (net), not including laps for splicing	42,300
Stakes 8 feet long	4,210
Pins 8 inches long, 1 inch diameter	8,420
Cubic yards clay, put in between layers of mattresses and brush	3,100
Barrels of clay for ballast	1,033
Cubic yards rock spread on top of dam	295

As the amount appropriated by act of June 14, 1880, and intended for operations at both points, viz, the raft and Tone's Bayou, will be insufficient for the purpose of keeping the raft open and at the same time completing the brush dam, it is proposed in the latter case, as the water above the dam is dead, to put in an earthen dam up to high-water mark with wings to prevent the action of the water around it. The bottom and banks of the bayou are of such a nature that unless a total closure be effected the overflow over a low-water dam will ultimately scour out such a hole below as to completely destroy the latter structure.

With the appropriation asked for for 1882 it is intended to keep the raft region clear of jams, and strengthen and keep up the earthen dike.

COMMERCIAL STATISTICS.

Shreveport is the principal distributing city for Red River, and from September 1, 1879, to June 24, 1880, received a total of 93,580 bales of cotton, 10,360 of which were received by river from above Shreveport, 71,514 by wagon, and 11,706 by rail. Of this amount 92,444 bales have been shipped, 58,886 going by rail to the various markets and 33,558 by river. In addition to this, 15,378 bales of through cotton were received and forwarded, 11,288 by rail and 4,090 by steamboat.

The number of landings made at Shreveport by steamboat during this time is 189, viz: from above the raft, 51; from the lower coast, 63; from Jefferson, Tex., 3, and from New Orleans, 72. The New Orleans boats will carry on an average 1,200 tons each, and the others about 600 tons each.

The value of imports during the same time amounts to $12,679,000.

The above works are situated in the third collection district of Louisiana. The nearest port of entry is New Orleans.

The original detailed estimate for the removal of the raft (see my report for fiscal year ending June 30, 1876, also previous reports of Captain Howell) was $259,014, with additional items for keeping open the channel for fiscal year, $50,000; and for subsequent years it was estimated that from $10,000 to $25,000 would be required.

The former appropriations are as follows:

By act approved June 10, 1072	$150,000
By act approved March 3, 1873	80,000
By act approved June 23, 1874	50,000
By act approved March 3, 1875	20,000
By act approved August 14, 1866, for removing raft and closing Tone's Bayou	35,000
By allotment August 27, 1877, for closing Tones Bayou	4,500
By act approved February 7, 1878, for removing raft	6,000
By act approved June 18, 1878, for removing raft and closing Tone's Bayou	24,000
By act approved March 3, 1879, for removing raft and closing Tone's Bayou	15,000
By act approved June 14, 1880, for removing raft and closing Tone's Bayou	25,000

Money statement.

July 1, 1879, amount available	$13,407 61	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$38,407 61
July 1, 1880, amount expended during fiscal year		11,772 85
July 1, 1880, amount available		26,634 76
Amount that can be profitably expended in fiscal year ending June 30, 1882:		
For closing Tone's Bayou	$20,000 00	
For removing raft in Red River	10,000 00	
		30,000 00

O 2.

IMPROVEMENT OF CYPRESS BAYOU, TEXAS AND LOUISIANA.

In August last a working party was organized, and George Alban, an experienced pilot, placed in charge. The party continued at work until the end of September, working from Bois d'Arc Pass through the lakes to Cross Bayou. They cut and removed from the channel 2,102 stumps and snags, 326 overhanging trees were cut down and removed, and 66 posts put up with painted sign-boards securely nailed to them to designate the route across the lakes. This finished the first project to improve the high-water channel.

Up to last year seven important cut-offs have been made, viz: 1, Potato Bend; 2, Little Cypress; 3, Middle Cypress; 4, Sisco Island; 5, Upper Benton; 6, Lower Benton; 7, Bois d'Arc Pass. These cut-offs and cut-roads across the lakes have reduced the distance from Shreveport to Jefferson from 96 to 65 miles. For this work the government appropriated $94,000, a small balance of which still remains, also a dredgeboat, the Lone Star, constructed for the work, valued at $20,000. The dredgeboat is now engaged at the mouth of Red River to keep the channel open during low-water.

Had the condition of commerce and navigation remained the same as in 1870 the work done would have been very valuable, for at that time Jefferson, and for 300 miles around, was entirely dependent upon navigation for obtaining their supplies and shipping their produce to market, New Orleans being the principal market city. Navigation across the lakes was open from six to nine months in the year, but the channel was difficult and dangerous, and, in order to improve their only transportation route, Jefferson expended over $70,000. When navigation was open flour could be obtained in the city from $10 to $12 per barrel; when closed it sometimes rose as high as $25, and other produce in proportion.

Since the commencement of the work of improving the bayou, Red River Raft has been removed, adding over 500 miles of navigable water to the river, but this has been gained by injuring the water route to Jefferson, for navigation across the lakes and through Cypress Bayou depends entirely upon the backwater from Red River running through the numerous bayous into the lakes. This water was forced through by the raft, but since its removal the water runs swiftly off. The channel in Red River is gradually scouring deeper, and the bayous into the lakes filling up; this has already greatly reduced the navigable season, and in a few years it may be entirely suspended.

This would have been a serious check to the prosperity of Eastern Texas in 1870, which had to depend upon the steamboats to ship its

produce and obtain its supplies, but since that date Saint Louis has constructed a railroad running through Jefferson, and now over three-fourths of the business is done by rail to Saint Louis.

To show how business has been changed by the Saint Louis Railroad, I give cotton statistics of Saint Louis for the last ten years:

Years.	Cotton.	Years.	Cotton.
	Bales.		*Bales.*
1869-'70	18,518	1875-'76	245,209
1870-'71	20,270	1876-'77	
1871-'72	86,421	1877-'78	266,314
1872-'73	59,700	1878-'79	331,000
1873-'74	103,741	1879-'80	470,000
1874-'75	133,966		

Before the Saint Louis Railroad was constructed the principal part of this cotton was shipped by steamboat down Cypress Bayou, Red, Ouachita, and Arkansas rivers to New Orleans.

New Orleans, in order to regain a portion of the trade lost, is now constructing a railroad into Eastern Texas, so that with two competing railroads the navigation across the lakes to Jefferson can never have that importance it had in 1870, although it will still remain valuable in assisting to develop the resources of the country.

Should any further work be done for the improvement of navigation it would require to be by extensive works such as recommended by Major Howell, this project being to construct a dam across the lake at Albany Point and make a cut through to Red River, the estimated cost being $372,580.

This would give Jefferson navigable water nearly all the year round, and would greatly benefit Red River above and below Shreveport. By placing a dam across the lakes they would act as large reservoirs, drawing and retaining the water at a high stage, thus greatly relieving the low lands below Shreveport from overflow and by running slowly off through the cut road retain the river at a medium stage much longer than at present.

Should the work once be begun it would have to be pushed vigorously forward, for the dam could not be constructed before the outlet was made into Red River, and in making the cut road the material removed would be required for the construction of the dam.

If the work be begun the amount of money required should be made available in one appropriation for the successful execution of the work.

The former appropriations are as follows:

By act approved June 10, 1872	$10,000
By act approved March 3, 1873	50,000
By act approved August 14, 1876	13,000
By act approved June 18, 1878	15,000
By act approved March 3, 1879	6,000

COMMERCIAL STATISTICS FOR THE CITY OF JEFFERSON FOR THE YEAR ENDING JUNE 30, 1880.

Sale of groceries	$1,315,000
Sale of dry goods	1,261,000
Sale of clothing	166,000
Sale of drugs, medicines, &c	271,000
Sale of hardware, farming utensils, &c	417,000
Amount of banking capital	200,000

Number of cotton bales received, 69,317; population, 3,400.

For collection district and port of entry see report on removal of raft in Red River and closing Tone's Bayou, Louisiana.

Money statement.

July 1, 1879, amount available	$7,173 71
July 1, 1880, amount expended during fiscal year	2,824 67
July 1, 1880, amount available	4,349 04

O 3.

IMPROVEMENT OF MOUTH OF RED RIVER, LOUISIANA—TEMPORARY IMPROVEMENT.

In order to keep open a channel through the outer and inner bars during the season of low-water, the United States dredgeboat Lone Star, which had been used in the improvement of Cypress Bayou, was towed from Jefferson, Tex., to the mouth of Red River, Louisiana, by the steamer T. B. Florence, arriving there June 20, 1879. So soon as the water fell to a suitable depth dredging through the bars commenced, and continued from July 3 to November 28, when the Mississippi River commenced rising, giving a good navigable channel, and operations were suspended.

During the time the dredgeboat was at work the amount excavated through the bars was as follows:

	Cubic yards.
August	15,646
September	14,410
October	16,238
November	11,509
Total	57,803

The low-water season of last year was the lowest on record, with the exception of 1872. Considerable difficulty was met with on the work, but every exertion was made to keep this important channel open. Had the dredgeboat been supplied with self-propelling machinery, no difficulty would have been experienced in keeping the channel open. The distance from the outer bar to the inner obstruction at the gut was, however, too great for the dredge to be moved quickly from one position to the other as the places filled up.

In January, 1880, the dredge was taken to Shreveport, and returned to the mouth of the river in June.

So soon as the water falls sufficiently to admit of operations, 2 tugs and a steamer will be employed in keeping the channel open.

COMMERCIAL STATISTICS.

All the cotton and freight transported to and from New Orleans, as shown by the reports for removing raft in Red River, improving Ouachita River, Arkansas and Louisiana, and removing obstructions from Red River, Louisiana, passed out through the mouth of Red River. A large amount of sugar, molasses, cattle, &c., was also brought out by the Opelousas and Atchafalaya boats, to which should be added a proportionate amount of return freight.

The trade of the Red River and its tributaries with New Orleans, passing through the mouth of Red River, is estimated at $50,000,000.

The port of entry is New Orleans.

Entrances and clearances at port of New Orleans, La., from July 1, 1879, to June 30, 1880, and tonnage of same.

	No.	Tonnage.
Steam vessels entered	451	795,450
Sailing vessels entered	725	402,979
Total	1,176	1,198,429
Steam vessels cleared	575	819,915
Sailing vessels cleared	722	397,456
Total	1,297	1,217,371

STATEMENT OF COMMODITIES IMPORTED AND EXPORTED, PORT OF NEW ORLEANS FROM JULY 1, 1879, TO JUNE 30, 1880.

Imports:	
Specie	$230,901 00
Free commodities	4,625,596 00
Dutiable	5,723,419 00
Total imports	10,579,916 00
Exports:	
Domestic commodities	9,238,757 00
Foreign	176,443 00
Total exports	9,415,200 00

Total amount collected on imports from July 1, 1879, to June 30, 1880, $2,080,598.57.

The former appropriations are as follows:

By act approved June 18, 1878	$150,000
By act approved March 3, 1879	40,000

Money statement.

July 1, 1879, amount available	$173,725 94
July 1, 1880, amount expended during fiscal year	12,845 94
July 1, 1880, amount available	160,880 00

LETTER OF THE SECRETARY OF WAR.

WAR DEPARTMENT,
Washington City, May 3, 1880.

The Secretary of War has the honor to transmit to the United States Senate, in connection with his letter of the 18th ultimo, forwarding report of Maj. W. H. H. Benyaurd, Corps of Engineers, upon a survey and proposed improvement of the mouth of Red River, Louisiana (printed in Ex. Doc. 126, Senate, Forty-sixth Congress, second session, copy herewith), a communication from the Chief of Engineers, dated the 28th ultimo, submitting a copy of report of the Board of Engineers for Fortifications and for River and Harbor Improvements, to whom Major Benyaurd's letter was referred, in further elucidation of the subject.

The suggestion of the Chief of Engineers, that the unexpended balances of the appropriations of June 18, 1878, and March 3, 1879, amounting to about $155,000, be applied to the improvement of the mouth of Red River, in dredging, &c., has been approved by this department.

ALEX. RAMSEY,
Secretary of War.

The PRESIDENT *of the United States Senate.*

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington D. C., April 28, 1880.

SIR: Referring to my letter of March 17, 1880, submitting the report of Maj. W. H. H. Benyaurd, Corps of Engineers, upon a survey and proposed improvement of the mouth of Red River, Louisiana (printed as Ex. Doc. 126, Senate, Forty-sixth Congress, second session, copy herewith), it will be seen that the plan recommended by that officer for permanent improvement was—

> To close the mouth of Old River, between the Atchafalaya and the Mississippi, and by locks on the Plaquemine, to make that the route to Red River, via Grand River and the Atchafalaya, leaving the mouth of Red River out of the proposed improvement, except the work of building a dam across Old River.

It was, as may also be seen, then stated that—

> The whole subject of the feasibility of this route and of its sufficiency and adaptability as a permanent channel of communication between the Mississippi and Red rivers will be referred to a Board of Engineer Officers for opinion thereon before deciding upon the further application of the appropriations of June 18, 1878, and March 3, 1879, of which there remains an unexpended balance at this time of about $155,000.

I have the honor accordingly now to submit the inclosed copy of the report of the Board of Engineers for Fortifications and for River and Harbor Improvements, &c., to whom Major Benyaurd's report was referred, and to respectfully suggest that it be submitted to Congress in further elucidation of the subject in hand.

The Board, as will be perceived, does not recommend Major Benyaurd's plan, for reasons which, in my judgment, are satisfactory, and in which I concur. I beg, therefore, to suggest that the funds now available be applied to the improvement of the mouth of Red River by dredging, and to the measurements, &c., recommended by the Board of Engineers.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY,
Secretary of War.

REPORT OF THE BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS
AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, April 20, 1880.

GENERAL: By your letter of March 17, 1880, the subject of the improvement of the mouth of the Red River, Louisiana, appropriations for which were made by acts of Congress approved June 18, 1878, and March 3, 1879, was referred to this Board for an expression of opinion thereon. Accompanying the letter was the report of the engineer in charge of the work, Maj. W. H. H. Benyaurd, Corps of Engineers, dated February 12, 1880.

Prior to the date of the first of these appropriations no special action had been taken by the United States Government in this matter, but it

had long engaged the attention of the Board of State Engineers of Louisiana. It has been noticed, and occasionally discussed, in the annual reports of that body, and considerable sums have been expended by the State in works designed to improve the navigation in Old River, where the principal difficulty is encountered.

Major Benyaurd's report so well explains the topographical features of the locality, and so clearly states the results of his own surveys, conducted to throw light upon the complicated hydraulic conditions affecting the problem, that no recapitulation is required. Some additional facts drawn from other sources, and certain collateral questions not discussed by him, merit attention before proceeding to consider his plans of improvement.

Adopting the mean level of the Gulf of Mexico as the plane of reference, the elevation of the high-water surface of the Mississippi at Red River Landing is 49.5 feet, and of the low-water surface only 5.2 feet. At Plaquemine these quantities are 30.6 feet and 1.9 feet, respectively; and at Indian Village, only 8.5 miles below, on Bayou Plaquemine, they were 10.4 feet, and about 1.5 feet before its closure in 1865. At Butte la Rose, where the Atchafalaya changes its name to Grand River, they are 8.8 feet and 2.2 feet. At the mouth of Black River, 30 miles above the proper mouth of Red River, they are about 54 feet and 9 feet. At the upper mouth of the Atchafalaya, 6.5 miles from Red River Landing, the high and low water level is somewhat variable in different years, even when the total volume passing southward is the same, being dependent upon the relative conditions of the Mississippi and Red rivers; but the average values differ but little from those at Red River Landing, say 49 feet and 5 feet.

Speaking generally, these figures indicate that when the Mississippi is at its lowest stage the level of the Gulf practically extends to the mouth proper of Red River, and that when it rises to its flood stage, 50 feet above this plane at Red River Landing, a vast swamp basin, extending southward from Butte la Rose and connecting with the Gulf, exists on its right bank and at the nearest point at no great distance from its channel; also, that this basin is so well drained by the net-work of bayous leading to Grand Lake, and thence through Berwick's Bay to the Gulf, that the water never rises upon an average more than 6 or 8 feet, even when the Atchafalaya is in full flood, and when the immense Mississippi crevasses, which always occur at such seasons, are discharging large volumes of water into this region, already filled by local rains. The Atchafalaya and La Fourche at present, and the Plaquemine before its closure in 1865 as well, are, therefore, to be regarded as waste-weirs, which carry off a part of the surplus flood volume of the Mississippi, and thus tend to protect the whole region bordering that river for a distance of 300 miles above the passes. These facts render it clear that before any project contemplating the closure of the Atchafalaya, as an outlet of the Mississippi can be even entertained a close study of its hydraulic functions must be made.

Perhaps the earliest map extant showing the efflux of the Atchafalaya is that made in 1578 by the monk Ptolemy, a member of De Soto's expedition. Then, as now, the stream served as a waste-weir of the Mississippi, and succeeding maps show that no material change occurred before 1831, when Shreve made his cut-off, which entailed the difficulties now so serious. The fact that its lower course was choked more or less by drift-logs until 1839–'40, when they were removed by the State, has no important bearing upon its value as an outlet, because the flood-water spread from the channel proper freely outward through swamp-drains

and over the banks, and thus reached the great basin level without seriously checking the current entering at the upper mouth. The dimensions of this mouth seem to be gradually enlarging, both by widening and deepening. Thus the effective high-water area of cross-section at this point in 1851 was 24,000 square feet, with a width of 730 feet; in 1859, 29,000 square feet, with a width of 830 feet; and by Major Benyaurd's survey it now (1879) appears to be about 45,000 square feet, with a width of 940 feet. The bed in this vicinity is of hard clay, which doubtless explains the reason why the change is so gradual, for the current is strong at the flood-stage—about 4 feet per second.

During the flood of 1858 the volume which entered the Atchafalaya was about 120,000 cubic feet per second, and at the same level it would now probably be not less than 180,000 cubic feet. The maximum discharge which has ever passed Red River Landing in the channel of the Mississippi (inundating the lower country by disastrous crevasses) is about 1,250,000 cubic feet per second, and the commission of engineers appointed in 1874 to investigate and report a plan for the reclamation of the alluvial region reported that provision must be made for about 1,400,000 cubic feet when the levees above are perfected.

In the great flood of 1851 Red River discharged 220,000 cubic feet per second when standing at Alexandria 1.1 foot below the highest point attained in 1849. These facts and figures should be borne in mind when considering Major Benyaurd's projects for the improvement of low-water navigation, for, although the latter object is of great importance, it is entirely secondary to the safety of the lower country against inundation.

Three flood combinations may occur at the mouth of Red River to endanger the lower country. (1.) The Mississippi may be at a dangerous height when Red River is low. (2.) Red Red may be very high when the Mississippi is bank full. (3.) Both rivers may have a coincidence in great floods.

Fortunately the first combination is most common, and in that case the Atchafalaya now performs the duty of an efficient outlet, and to that extent relieves the lower country. In the second case the Atchafalaya carries its full volume of Red River water, and any excess discharges into the Mississippi and passes off without seriously endangering either the Atchafalaya Valley or the plantations on the Mississippi. In the third case the volume to be carried off exceeds the discharging capacity of both channels, but nature divides the overflow between the Atchafalaya and Mississippi in an equitable manner, which leaves no just ground of complaint between the respective proprietors of the land submerged.

Major Benyaurd's first plan is to separate the Red River and Atchafalaya by a low-water dam, thus forcing the former to flow into the Mississippi through Upper Old River and a cut to be artificially prepared. This would not affect the first flood combination, but neither the second nor the third would be as favorable as at present, because the increased discharge might interfere with the local slope of the surface of the Mississippi at Red River Landing, and thus might raise the level anomalously from 1 to 2 feet, as actually occurred in 1851 (see Physics and Hydraulics of the Mississippi, p. 385). There are other objectionable features in this plan. The fall between the mouth of Black River and that of Red River proper in both flood and low-water stages is 4 feet in 30 miles, or at a rate of 0.14 foot per mile. By adding the 5.5 miles to the length of the stream, contemplated by this plan, the flood surface of Red River must be raised and the low-water slope sensibly diminished. The latter would aggravate the tendency to form troublesome bars in the new mouth, which

formerly existed in the old mouth proper. This plan has been favored by the Board of State Engineers of Louisiana, but, in view of its uncertain efficacy and certain defects, we agree with Major Benyaurd in not recommending it.

Another plan submitted by Major Benyaurd, and, indeed, recommended by him for adoption, consists in closing both mouths of Old River, thus permanently separating the Mississippi from Red River and the Atchafalaya, which are hereafter to constitute a single stream. Navigation between the Red River country and New Orleans is to be secured at all stages by the canalization of old Bayou Plaquemine, thus opening a new route through Grand and Atchafalaya rivers.

When this project is brought to the test afforded by the possible flood combinations of the three rivers, it is at once seen to be inadmissible. In the first and most common case, the Atchafalaya might be at a low-water stage while the Mississippi plantations were suffering ruin from crevasse water that would now escape by the channel of the former without injury to any one. In the second case, the Atchafalaya country might be inundated by a Red River flood, the surplus water of which would now pass down the Mississippi without damage. In the third case, claims for damages might justly be brought by the land proprietors who had suffered in consequence of the arbitrary partition of the surplus volume. In the judgment of the Board this plan, or any other which looks to the closing of the Atchafalaya as a high-water outlet, should never be entertained.

A modification of this plan, suggested by Major Benyaurd, is free from this objectionable feature. Matters are to be left to nature where the three rivers come together; but the Plaquemine canal is to be constructed for use at low stages, when the open mouth of Old River becomes unnavigable. At high-water stages the present route is to be used.

This plan merits careful study. Assuming that at low stages the Atchafalaya now affords in the lower part of its course as good navigation as Red River—a point not discussed by Major Benyaurd, and concerning which the Board has only the information contained in the report of Major Howell, Corps of Engineers, forming Appendix R 14 to the Report of the Chief of Engineers, for the year ending June 30, 1874—his surveys show a water-route to connect it with the Plaquemine, which could be made good at a moderate outlay. Indeed the only difficult features of the project are the construction of the locks at Plaquemine to withstand the considerable oscillation of the Mississippi (at least 30 feet should be provided for) and the protection of Plaquemine bend against caving, which now appears to be serious. In this connection the following from the report of the Board of State Engineers of Louisiana for 1876, is quoted:

> It may be well to state here that a most damaging cave took place in the town of Plaquemine on the 23d of this month. The cave occurred in the evening, and carried away about 12 buildings, fences, &c., and a front through the main portion of the town of about 1,400 feet, and in horizontal depth about 140 feet. We have located a levee behind this cave and along Bank street, and were obliged to throw out about 50 buildings in order to secure any permanency to the levee.

Major Benyaurd's estimate of the cost for this plan is $457,264.66, which is thought by this Board to be much below what the actual construction would involve.

Another project presented by Major Benyaurd is to leave the water-courses as they are at present, and to depend upon local dredging to maintain low-water navigation through Lower Old River. The esti-

mated cost for a single season of working the two dredges needed is only from $10,000 to $15,000.

The gradual increase in cross-section of the efflux of the Atchafalaya suggests a tendency to an increased flow through this channel at low-water stages, which may naturally improve the depth in Old River, and thus modify the conditions of the problem as now presented. Experiments heretofore made in this vicinity in the interests of navigation (Shreve's Cut-off in 1831, and Raccourci Cut-off in 1848) have resulted disastrously, and indeed the hydraulic conditions are so complex that it is not easy to predict in advance what will be the permanent effect of any artificial work.

For these reasons the Board recommend that the funds now available be expended in dredging according to Major Benyaurd's project; and that careful measurements be made, and frequently repeated, for about 3 miles down the efflux of the Atchafalaya and in Lower Old River. The plan should be tried with a competent force and sufficient yearly expenditure to make a thorough and conclusive test. Information will thus be secured which will afford hereafter better grounds for deciding upon the necessity of more costly plans of operations than any now available.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brevet Major-General.
JOHN NEWTON,
Colonel of Engineers, Brevet Major-General.
HENRY L. ABBOT,
Major of Engineers, Brevet Brigadier-General.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MAJOR W. H. H. BENYAURD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., February 12, 1880.

GENERAL: I have the honor to present the following report upon the improvement of the mouth of Red River, Louisiana, appropriations for which were made by acts of Congress approved June 18, 1878, and March 3, 1879.

Up to the time of the first appropriation no survey of the locality had ever been undertaken by the department, or by the direction of Congress, looking to the assumption by the government of the work of improvement heretofore carried on by the State of Louisiana, and the estimates then presented were based upon the reports and plans made under the direction of the Board of State Engineers. This body had had the matter under consideration for many years, and while numerous plans and estimates had been presented, no work except of a minor character had ever been attempted. In 1874, E. H. Angemar, assistant State engineer, presented to the State Board a plan (though without estimates), which was approved "as by far the cheapest and simplest plan," and it was upon this that the estimates presented to Congress were based. The plan seemed perfectly feasible and practicable. Essentially it was to build a low-water dam from Turnbull's Island to the main land between the old mouth of Red River and the Atchafalaya, and to turn Red River down the upper channel above Turnbull's Island.

Upon the work being assigned me, I directed a survey to be made

of the entire locality, embracing the old mouth of Red River, the upper and lower channels around Turnbull's Island, the head of the Atchafalaya, and the mouth of Old River, and the Mississippi in the vicinity, with a view of gaining all possible information covering the actual condition of affairs and the best method of carrying out the work of improvement.

The survey upon which the maps and drawings herewith presented are based was commenced in July following the announcement of the appropriation. High-water for a while interfered with the work, and afterwards the yellow fever prevailing at Red River Landing and vicinity caused me to withdraw the party from the field and abandon the survey until a more favorable season. It was recommenced in December and finished the following February (1879). The parties were brought to the office and the drawings and plans worked up from the notes. The results showed that many changes had taken place since 1874, and that the conditions were very unfavorable for carrying into successful execution the above-mentioned plan. The vast interests at stake, involving the commerce of the Red, Black, Ouachita, Atchafalaya, and their tributaries, demanded that other routes possessing favorable features should be examined before finally determining upon a definite plan. Considering that the one suggested by Mr. J. K. Duncan, when chief State engineer, of taking Bayou Plaquemine as the route to Red River, presented many excellent points, I concluded to have that route surveyed, and accordingly in July I dispatched a party to the Plaquemine for that purpose. The results of this survey will be noticed further on.

As a history of the changes or causes that led to the destruction of the navigation of the mouth of Red River will be necessary for a proper understanding of the questions involved, I will give extracts bearing upon the same, taken from the various reports of the board of State engineers of Louisiana.

In an elaborate report upon the origin and causes of the deterioration of the navigation of Old River (as the channel is now called), by Mr. J. K. Duncan, in 1860, he states:

I am unwilling to admit a mere speculation in this report, but in as far as the question of original unity between the Red and the Atchafalaya rivers is concerned this is unavoidable. History and tradition at the remotest dates found the same indirect separation of these rivers as there is at present, for no direct evidence of a more perfect connection between them has ever come down to our times. Hence our deductions regarding this former unity can now only be based upon a careful inspection of the present geography and geology of the valleys of the two rivers in question. A close examination and comparison of the physical aspects and the geological formations of these valleys leads one inevitably to the conclusion that there was a former time when the Red and Atchafalaya rivers were one and the same stream, which had no connection with the Mississippi whatever, except through lateral overflows in extreme floods. It is not presumed by this that there were not other outlets to Red River besides the Atchafalaya during the outward progress of the whole front of its delta.

The Teche, in all probability, was such an outlet up to a very recent period comparatively; but upon due investigation of the subject, however, the conviction will force itself upon every one that, as the land extended outward, the Atchafalaya became the final and only remaining one of these outlets.

I am aware that this former unity between the Red and the Atchafalaya rivers has been questioned by several able and scientific writers. The problem of low-water navigation, which remains to be solved, however, depends upon the present existence of things and not upon the changes of the past, and therefore it is immaterial whether this premise be admitted or not, as it will be fully proven hereafter that these two rivers form one and the same stream now, which will be sufficient for our argument. The Red and the Mississippi rivers then occupied separate valleys, running generally parallel with each other, but with no immediate connection between them. The latter sought the Gulf at the Balize, through its own independent channel, while the former reached the sea through the Atchafalaya and Berwick's Bay.

The general tendency of alluvial streams is ever to lengthen their courses and reduce

their slopes. As a consequence of the tortuous meanderings resulting from this consideration the Red and Mississippi rivers came together and mingled their waters In thus coming together, however, it must be borne steadily in mind that the former was completely cut into two parts, and that the bend or loop of the Mississippi, now called Old River, separated these parts by a distance of about 3 miles, and thus maintained an indirect communication only between them. For easy nomenclature, we will designate these parts by the names by which they are now known; that is, we will call the upper one Red River and the lower the Atchafalaya.

The natural effects which would be produced by the meeting of the waters of the Red and Mississippi rivers would be as follows:

EFFECTS UPON THE ATCHAFALAYA.

As the Atchafalaya flowed directly from the apex of an abrupt bend of the Mississippi, which then, as now, constituted its source or head, it is evident that after the meeting mentioned it would become the general recipient of most of the floating drift coming down the Mississippi during the rise of its floods. The inevitable result of this would be the complete rafting of the Atchafalaya from Berwick's Bay to its head. Everything proves this dense rafting to have taken place, traces of which are apparent throughout the entire course of the river, in its lake formation, and in its numerous lateral chutes caused by the water breaking around the rafts and coming in again below them. This has been known to be the case up to a very recent date, as but a few years have elapsed since the rafts were broken and removed by the internal department.

These obstructions would render the current of the Atchafalaya very sluggish, whence there would be a consequent rapid deposition of sediment upon the rafts, causing the channel of the river to contract and shoal its bed.

EFFECTS ON THE RED RIVER.

It is plain that when their waters first came together the inevitable result would be the absorption of the Red by the Mississippi, and a rush of most of its waters down the stream of the greatest slope and velocity.

This becomes the more evident when we reflect that the Red debouched directly into the Mississippi, and that it was furthermore completely cut off from its natural outlet, the Atchafalaya.

As the Mississippi at that time swept entirely around the bend now called Old River, and as the Atchafalaya became rafted in the manner before shown, the Red River would continue to flow into it as a forced tributary until some subsequent great change should divert its course and direct it elsewhere.

Throughout all the delta of the Mississippi it is well known that its banks fall rapidly back from the river laterally, and consequently the parallel back valley must be on a lower level on the same parallel of latitude. Hence the Red River, running through this lower valley, must necessarily be below the Mississippi, and this being universal on every parallel it is evident that the plane of its slope has a less inclination also. In consequence, during its floods and even at low-water the Mississippi would back up its waters into the former, and, as these back waters had no natural outlet, they would be forced up the Red, Black, Ouachita, and Little rivers, and their numerous branches, perhaps for many miles. This would produce a constant retardation of the current of Lower Red River and a consequent precipitation of the earthy matter held in suspension, as this latter is lifted and carried along entirely by the velocity of the current, or by the mechanical action of the water in motion, as we have before seen. These depositions would cause the lower part of its channel to shoal; and the waters coming down from above, together with the back waters from the Mississippi, finding no sufficient vent, would escape in a sheet, flow over the banks into the low-bordering swamps, thus converting nearly all of this entire region into one vast reservoir, as far as the retardation extended.

The sudden accession of the waters of Red River to its volume would cause the Mississippi to change its regimen. This change could not have been very great or sudden, however, as the Atchafalaya, until it became rafted, partially compensated for the accession from Red River. In time this river accommodated itself to the new order of things, discharging its surplus in the meanwhile over both of its banks into the low swamps beyond.

It is plain, furthermore, that at that time there could have been no question of low-water navigation, excepting at the mouth of and in Lower Red River, as what is Old River now was then the Mississippi.

Such had probably been the condition of these rivers for ages, and this was their condition and their several relations at the time they were first discovered by the Europeans, and thence up to the year 1831, when our troubles regarding navigation began to be really serious.

At this time, 1831 (see map A), the Mississippi formed the loop alluded to, *received* at its upper bend the waters of Red River, directly, and from its lower end *emptied* its own water directly into the Atchafalaya. The distance around the bend was about 17 miles, while across the narrow neck of land it was but a few hundred yards. The Atchafalaya was, as stated, completely filled with raft, and at the same time a bar was forming at the mouth of Red River, and its lower reaches were becoming shoal from the deposition of sediment. To improve the navigation of the mouth of Red River, recourse was had to the Shreve Cut-off, which was made over the narrow neck of land. Of this, Duncan says:

To improve the navigation at the mouth of and in Lower Red River, which was rapidly deteriorating from the deposition at its mouth, caused by checking the current, as we have before seen, recourse was had to this popular but pernicious method of obtaining immediate relief.

A perfect cut-off produces, together with other results, a sudden fall of the whole river at and above the point where made.

It is hence evident that there would result temporarily from this work the immediate benefit required. The Mississippi having suddenly fallen at the mouth of Red River, there would necessarily be less back water in the latter, and consequently an increased current and greater fall. Red River would, therefore, tend to free itself from the shoal bars at its mouth, and to wash out the light deposits which had accumulated in its bed for some distance above. This benefit could not of necessity be permanent or lasting; for by thus throwing the Mississippi further to the east, it was partially separated from Red River, and to a certain degree both rivers were forced to assume their original independent channels.

Several natural causes would tend to widen if not to complete the separation, two of which, especially, were prominently active:

First. The tendency of the Mississippi to close up the gorges of its old bend by annual deposits in them. This is an invariable law which operates in every cut-off, whether natural or artificial, and of the effects of which Lakes Saint John and Concordia, in the parish of Concordia, a short distance above, may be instanced as perfect specimens on the Mississippi. There are many other similar cut-offs throughout the State which have completely closed their gorges by this same process, and which are familiar to every one.

Second. The renewed efforts of the Red River to reach the Gulf by the lower levels of the Atchafalaya, from the increased activity which it received under this change of regimen and artificial separation. Additional power and increased activity were also given to the operations of these natural causes by the labors of man; for in 1833, two years after the cut-off had been made, a board of public works was incorporated under which the internal improvements of the State began to be developed. The removal of the rafts obstructing the Atchafalaya and Grand rivers and Bayou Sorrel being urgently demanded by the necessities of the case was among the earliest of its operations. In order to open the navigation through these streams to the Attakapas, a labor required by an increasing population, man performed by the removal of these rafts that which nature was unable to do without such assistance, as we have before seen.

When these rafts were partially broken and removed the increased current velocity of the Atchafalaya soon washed out the light deposits in its channel. By the annual assistance which it received from the internal improvement department, this river rapidly assumed its original capacity to vent the waters of Red River, with an increased ability to carry off the back waters discharged into the Red River basin by the Mississippi. The efforts of both of the latter rivers were joined in the same direction; the Red River, striving to regain its natural outlet by the lower levels of this valley, supplied water and current for the abrasion, and the Mississippi, by using the Lower Red and all of Old River as a reservoir, greatly weakened and retarded the currents in the latter, and hence there resulted a rapid precipitation of alluvial deposit and consequent shoaling throughout the entire channel of Old River. Its lower gorge was closed in a few years, while bars and shoals were more gradually forming in the upper gorge, and islands and shoals in all that part of its channel from the mouth of the Red River to the Mississippi. Besides, the Mississippi kept receding further to the east by a vigorous abrasion of its left bank, while as rapidly batturing the right bank and filling the gorges of its old bend, until it has taken up an equated position at some considerable distance from the place where Shreve originally cut his channel.

It is plain from these facts that this cut-off, together with the removal of the Atchafalaya rafts, had in a great measure restored the Red and Mississippi rivers to their primary condition before the meeting of their waters, giving each a tendency to the

Gulf by its own independent channel. The connection of the Red and Atchafalaya with the Mississippi was made to depend entirely upon the navigation of the old bend of the latter, now called Old River. This was rapidly filling up from the effects of natural causes. In short, the cut-off had only transferred the difficulty from the mouth of the Red to the channel of Old River, and had greatly impaired the navigation instead of improving it.

Among the many plans suggesting themselves for the amelioration of the low-water navigation of Old River, it is singular that no other method could be thought of than the recurrence to a second cut-off, especially after the experience of the fatal consequences of the first. With this object in view, however, the Raccourci cut-off was proposed and finally completed in 1847.

Here is another instance of hasty legislation, rushing into unknown and greater evils merely to escape for the moment an existing one. Notwithstanding the efforts made by P. O. Hébert, State engineer, to arrest the progress and final execution of this work, and in spite of the warnings of other engineers of scientific attainments, who cautioned the legislature that this proposed cut-off would not produce the benefits expected of it, but that it would only cause the inundation of Lower Louisiana, still this last crowning work was ordered into execution.

As was predicted of it, and as might have been anticipated from the character of its effects, this work led to an early and complete separation of the Red and the Mississippi rivers, by giving additional power and activity to all the causes which we have seen in operation, assisting them the more rapidly to destroy the very navigation through Old River which it had been made to improve.

This cut-off was completed in 1847. Since then Old River has filled up, not gradually but with extraordinary rapidity. Every river pilot will confirm this; and it is, furthermore, attested by the annual legislation invoked by general complaint for its improvement. Since that time, furthermore, the rafts in the Atchafalaya have been completely broken, and to a great extent removed, so that its channel is now widened and deepened to something like its original capacity and magnitude.

In consequence, therefore, of the making of these cut-offs, and the removal of the Atchafalaya rafts, nature has at length triumphed in the execution of her universal and unchangeable laws. And while the legislatures of 1859 and 1860 were passing acts anticipatory of a separation of the Red and Mississippi rivers, that result had in reality already taken place for all the practical purposes of low-water navigation, and the waters of the Red and the Atchafalaya were effectually blended into one stream, flowing majestically in one unbroken channel of over 2,000 miles from the Rocky Mountains to the Gulf of Mexico.

This has probably been the case for several years past; and it will be endeavored to be proved further on in this report that this separation has been anything but a misfortune to the best interests of the State.

CHANGES THAT HAVE TAKEN PLACE IN OLD RIVER SINCE THE SHREVE CUT-OFF.

Previous to that event, Old River, which was then the bend of the Mississippi, was upwards of three-fourths of a mile wide and 80 feet deep. After the cut-off the bend commenced to fill up very rapidly, so much so, that in 1839, eight years after, State Engineer Dunbar reports that on the 18th of January of that year he found 5½ feet of water over the bar at the mouth of Red River, 5½ feet on the bar of the Atchafalaya, 18 inches over the bar at the lower mouth, and 10 feet over the bar in the upper mouth, showing a difference of 4½ feet between the bar in the upper mouth and the bar in the Atchafalaya.

On the 13th of February of the same year he found 10 feet of water over the bar at the mouth of Red River, 17 feet in the upper mouth with no current, 12½ feet in the mouth of the Atchafalaya with a strong current, and 4½ feet over the bar at the lower mouth, showing an increase of deposits on the bar at Red River of 2 feet and one of 3½ feet on the bar at the lower mouth, while the relative depths of the Atchafalaya and the upper mouth remained the same. The estimate was based upon the supposition that the bar in the Atchafalaya, being composed of hard blue clay, would not cut by the action of the water.

By his examinations in the following year (1840), he found that the main part of the lower mouth was 2½ feet out of water, the balance was

entirely dry, with the exception of a small communication about 10 feet wide on the level with the surface of the water. The soundings showed a depth of 7½ feet in the channel over the bar in the upper mouth, 6 inches of water on the shoalest part of the bar at Red River, and 5½ feet on the bar in the Atchafalaya, showing a difference between the bars in the upper mouth and the Atchafalaya of 2 feet, and making a decrease of difference between the two of 2½ feet since January, 1839 (map B, showing locality in 1839).

The change and filling up continued, and navigation became so bad that during the years 1845, '46, and '47 it was virtually suspended during the low-water season. It was during the latter year that recourse was had to the Raccourci cut-off, as mentioned above. Instead of producing the desired effect of cleaning out the deposits at the mouth, it only hastened the more rapid filling up thereof.

The surveys made by L. Hébert in 1855 and '56 show still more the important change taking place and the further separation of the Red and Mississippi rivers.

In 1860, Duncan reports that on the 12th of August of that year the mouth was entirely closed to the passage of a small steamer, there being at that time but about 18 inches of water upon the bar. Measurements taken during the season after a steamer had plowed her way through gave an actual width of channel of 170 feet, a depth of 2.95 feet, and a sectional water area of 503 square feet.

Map C, herewith, made in 1866, shows still greater changes. The lower channel was completely closed at its mouth, the deposit being covered with a heavy growth of timber, communication being maintained between the Red and the Mississippi rivers through the upper channel, which was very narrow and shallow.

In 1872 the river forced itself through the narrow strip of land that obstructed the lower channel, and at the same time commenced filling the upper channel, which up to that year had been the route for the boats. Since that year the lower channel at low-water has been the main channel of communication.

In December, 1876, the river was closed to such an extent that three-fourths of the boats navigating the Red and tributary streams were detained at the obstruction, waiting for the river to rise.

In 1877 navigation became so difficult that the State made an appropriation to keep the channel open. In 1878 the government employed two tugs and a steamer for a month and a half for a like purpose.

In fact, it might be said that were it not for the temporary expedients resorted to from year to year, the navigation through Old River would have long before been destroyed.

CHANGES IN THE ATCHAFALAYA.

At the time of the cut-off, and for several years afterward, the Atchafalaya was a very small stream, filled with rafts, and almost unnavigable. It is reported that in 1839 the water was so low at the head of the stream that foot passengers, by means of a plank 15 feet long, could walk across it. In that year the State commenced removing the rafts and other obstructions, and immediately the river commenced widening and deepening, and is still continuing the process.

In 1850, Professor Forshey states that, from reported soundings, he found a mean *high-water* depth at the head of about 50 feet, with a width of 730 feet. Soundings made at the time of my survey show an extreme *low-water* depth of 85 feet and a width at surface of about 900 feet.

The maps, &c., herewith presented show the condition of the different channels at the time of the recent survey. The stage of water was then 5 feet above extreme low-water and the sections are referred to that stage, though low-water is at the same time indicated.

Starting in Old Red River proper above the head of Turnbull's Island, there was found a width of 940 feet and a depth of 23 feet, giving a sectional area of 14,080 square feet; a low-water section would be 9,650 square feet.

At the head of Turnbull's Island the channel separates into what are known as Upper Old River and Lower Old River, joining again at the foot of the island and flowing thence to the Mississippi in a single channel. In ordinary stages of water Upper Old River divides at its head into three channels, known respectively as the Sugar House Chute, Middle Chute, and the Straight Chute. In extreme low-water these are entirely closed and there is no navigation down Upper Old River.

Lower Old River is now the only navigable channel at a low stage of water, and at times, even through it, great difficulty is experienced, particularly on the lower reaches. In its upper part, say just below the head of Turnbull's Island, the lowest depth found was 13 feet at the stage above indicated. As we approach the head of the Atchafalaya we find a depth just above of 37 feet and just below of 27 feet, with corresponding sectional areas of 14,680 and 14,820 square feet.

The sections of the Atchafalaya at its head, and at a point 1,000 feet below, give respectively 52,100 square feet and 16,766 square feet. The large increase of the upper section is due to the eddy formed by the meeting of the water of the Red and Mississippi and scouring out a deep hole, the depth on this section being at low-water 85 feet.

After leaving the head of the Atchafalaya, the channel of Old River commences to shoal, and from opposite Chandler's Landing down to near the lower end of Turnbull's Island navigation is extremely difficult, particularly along the channel known as the Gut or Mud Hole, where for a distance of about 8,000 feet the channel varied in width from 250 to 400 feet, with a depth from 2½ to 3 feet at low-water. The bottom through this channel being covered with a layer of soft mud, through which the lightest sounding rod was easily pushed, rendered the operation of obtaining the sounding to extreme nicety very difficult.

From the Gut out until we reach the mouth we find a sufficient depth of water. At this point, however, we found only 4½ feet at the time of the survey (the gauge at Red River Landing being 5 feet above low-water), showing a possibility of a complete blocking up of the entrance, had the water been at its lowest stage. A reference to the maps will indicate, in much more detail, the soundings, cross-sections, &c., and will give a full idea of the situation much more readily than any description.

Considering the changes that have taken place in the channels of Red River, Old River, and the Atchafalaya from the date of the Shreve Cut-off down to the present time, it is evident that navigation of Old River has become more and more difficult from year to year, and threatens at no great future time to be utterly destroyed. In fact, had it not been for the work executed at different times, Old River would most undoubtedly have been closed up. It is estimated that the State of Louisiana has spent upwards of $1,000,000 in attempting the various improvements. These latter, however, were not of a permanent nature, but consisted mostly of dredging and scraping operations during the low-water season. The operations during the past three years, as carried on by the State and by the government, have been only with a view to keeping the channel open temporarily.

While the navigation of Old River has been deteriorating, that in the Atchafalaya has been improving, and this bayou has enlarged to such an extent that it now absorbs all the water of Red River (when at a low stage) in its endeavor to reach the Gulf by the shorter route down the Atchafalaya. I caused Red River below the mouth of Black River to be gauged when it was near its low-water mark, the result being a discharge of 10,775.25 cubic feet per second; the mean velocity being 1.191 feet per second, and the area of section 9,050 square feet. At the same time the gauging of the Atchafalaya, half a mile below its head, gave a low-water discharge of 16,950 cubic feet per second; or, in other words, the Atchafalaya was carrying off half as much water again as it received from Red River, the difference being from the Mississippi. The distance to the Gulf from the head of the Atchafalaya by way of Grand Lake and Berwick's Bay is 133 miles. The distance by way of the Mississippi is estimated at 326 miles. Under the old condition of affairs the waters of Red River may be said to have reached the sea with a fall of 1.84 inches per mile. That which now runs down the Atchafalaya falls at the rate of about 5.7 inches per mile.

From my observations it is evident that the Atchafalaya has again become an important outlet to the Mississippi River. The current now at all times runs *from* the Mississippi. It is only during the very exceptional time when the Red is high and the Mississippi low that any Red River water passes the head of the Atchafalaya and finds its way to the Mississippi. This has been doubted, but since my connection with the improvement I have not known to the contrary, and I believe this important change dates from the time (1872) when the river broke through the strip of land in Lower Old River, and made that the navigable channel. From a consideration of the conditions and relations of the different streams, it is evident—

First. That the low-water navigation of Old River is completely destroyed for all practical purposes, and that as the same causes are still operating it must necessarily deteriorate more and more every year.

Second. That the water supply of Old River is due to the Mississippi both at high and low stages, and not to Red River.

Third. That the Red and Atchafalaya rivers are unquestionably one and the same stream now, whatever may have been their former relations.

Fourth. And that there is a constant deposit at the mouth and in Lower Red River, owing to the retardation of its current by the back waters of the Mississippi.

Hence Old River can only be regarded as a communication between the Red, Atchafalaya, and the Mississippi during the continuance of high waters, at which time it also acts as a water-waste to the surplus floods of the latter.

The question then naturally arises what must be done to improve the low-water condition of Old River and maintain that channel as a navigable avenue of communication between the Mississippi and the Red.

While numerous plans have heretofore been presented to effect that object, the changes that have taken place from year to year have so modified the conditions upon which they were based that their consideration would be of no practical value, and therefore they will not be discussed. At the present time there are but two plans advanced, that is for the improvement of the immediate locality; that for the Plaquemine will be considered hereafter. These two plans are—

First. To build a dam across *lower* Old River below the head of Turnbull's Island, and force Red River down *upper* Old River, and thence by

a cut through into the Mississippi; thus leaving the communication between the Mississippi and the Atchafalaya by way of the lower reach of Old River. This was the plan lately presented, and was the one upon which the estimates were presented for the consideration of Congress.

Second. Dredging Lower Old River at its mouth and at the other points of obstruction, as a temporary means and to be resorted to every low-water season whenever the obstruction be sufficient to demand it.

The first plan involves the construction of a low-water dam across Lower Old River, the closing of the middle and straight chutes at the head of Turnbull's Island dam at lower end of Upper Old River, and the excavation of a cut through to the Mississippi. The dredging and excavation provides for a channel 200 feet wide and 5 feet below extreme low-water line. The estimated cost of this work is $361,828.79.

The effect of this work would in reality be only to transfer the difficulties from the lower to the upper channel, and at considerable expense. As it was observed even in former times that Red River had not sufficient velocity to clean out the deposits at its mouth, it is still more apparent that with the increased length of channel, and with its mouth moved some 5½ miles farther eastward, Red River could not be projected into the Mississippi with sufficient velocity to insure at all seasons an open channel. The causes that operate at the present time to fill up the gorges of Lower Old River would operate in the same manner with the upper channel, and, therefore, expensive dredging operations would necessarily have to be resorted to every low-water season. With this view of the case we might avoid the expensive work of attempting to turn Red River down the upper channel, and resort at once to attempt the maintenance of an open channel by the second plan, which contemplates *dredging*, or some similar process, such as scraping, harrowing, or stirring up the deposit, and inducing a current to carry the same off.

These processes have been resorted to more or less by the State for a number of years, and for the past three seasons by the State and by the government, at an expense of about $10,000 per year. A channel sufficiently large for the passage of the steamers navigating the Red and tributary streams was maintained. This past year, however, the extreme low-water in the Mississippi and other streams greatly added to the difficulty of keeping an open channel; and at one time the mouth of the river was completely blocked up.

Unless changes take place in the relative condition of the streams, whereby the Atchafalaya will again become an important outlet of the Mississippi, and there will be a constant and efficient current maintained *from* the Mississippi into the Atchafalaya through Lower Old River sufficient to keep that channel open, the work of dredging will become more and more difficult from year to year.

It is possible that the changes alluded to may be about to take place. During the low-water season of last fall, I kept my dredgeboat employed in keeping the mouth open. In the execution of this work, a channel was dredged through the bar and out several hundred feet into the Mississippi. Soon afterwards, the Mississippi commenced rising and a strong current was found setting in from the Mississippi towards the Atchafalaya. It was found also that the "Gut" was not so much of an obstruction as formerly, and that the soft deposit had been carried down to the "crossing" and in front of Chandler's Landing. Should this deposit continue to move towards the Atchafalaya, it is possible than an open channel may be maintained. At last advices, the Mississippi had risen at the mouth of Red River to a height of 33.65 feet above the standard low-water of 1872, Red River at the same time remaining very

low. The strong current and volume of water passing through Old River and down the Atchafalaya had the effect of alarming the planters along this latter stream, as they seemed to fear that the Mississippi would turn a great portion of this volume down that way. While they desired an open channel, they did not wish it at the expense of their plantations. At the present time it will be impossible to predict what effect this increased current and volume of water may have upon Old River and the Atchafalaya. Next low-water an examination can be made, and it may present a simpler solution of the problem of keeping an open mouth through Red River than any yet advanced.

Should it be advisable to continue the dredging operations it will be necessary to provide another dredgeboat in addition to that now in service; keeping one at the outer and one at the inner obstruction. The estimated cost of a new dredge is $40,000, and the cost of operating both is from $10,000 to $15,000, depending upon the length of the season.

BAYOU PLAQUEMINE ROUTE.

After considéring that the first plan, with its objectionable features, would not fulfill the conditions of maintaining a permanent channel, and that the second plan was but a temporary expedient, attention was directed to the Bayou Plaquemine, which, if improved, would possibly give good navigation via Grand River and the Atchafalaya from the Mississippi to the Red, and at the same time preserve the communication between the Mississippi and the Attakapas country.

The plan for the improvement of the route contemplates the closing of the mouth of Old River, either by natural causes or artificial means, and the canaling and locking of the Plaquemine, and the dredging of a portion of Grand River, and the removal of obstructions from the Atchafalaya.

Bayou Plaquemine was many years ago a mere overflow *coulé* choked with growing timber. To secure water communication with the Attakapas country this timber was removed, and ultimately an outlet having a cross-section of 6,000 square feet and carrying off 35,000 cubic feet of water per second was formed. The work in question was done by the Louisiana Navigation Company, under a charter from the State. The project for maintaining navigation throughout the whole year proved a failure, and was ultimately abandoned. As the mouth of the bayou was situated in an abrupt bend of the Mississippi, the banks at that point were eroded greatly by the force of the current, and, in addition, the bayou itself was being rapidly filled up with drift from the river, making navigation extremely dangerous and difficult. In 1865 the bayou was closed at its head by a levee, upon the ground that there was danger of its rapid enlargement, and that the back country would be endangered by the volume of water poured into it from the Mississippi. After the overflow of 1874 a new levee was built farther back for better protection.

At the foot of Bayou Plaquemine (11 miles) we enter Grand River, properly a continuation of the Atchafalaya, which, turning eastward at Butte á la Rose, runs through the lower part of the parish of Iberville until joined by the Plaquemine at a place called the Park; thence flowing southward, finally discharges into the lower end of Grand Lake. Grand River, after leaving the Plaquemine, is a small stream, varying in width in the first 5 miles from 65 to 125 feet, with a depth of not under 9 feet. From thence the river widens to 400 feet at the *third flat*, and from this point to Osca Bay it has a width of from 600 to 900 feet,

with a depth from 15 to 40 feet. From Spoil Bayou to the Little Atchafalaya the width of the river is from 300 to 500 feet, and at Butte á la Rose 900 feet wide. Both sides of the river, from the foot of the Plaquemine to the Big Pigeon, are wild, low, and swampy; from Big Pigeon up to La Raurpe the right bank is partly cultivated, the strip of land varying from 1,200 to 3,000 feet in width, back of which we find the bottom land; back of that, swamps. Cow Island, and the land in the vicinity of Butte á la Rose, lie from 10 to 14 feet above low-water. The difference in elevation of the surface of low-water in the Mississippi at Plaquemine and that at Butte á la Rose varies very little, say only 0.33 of a foot.

The difference between high and low water in the Mississippi River at Plaquemine is 28.7 feet. The difference in elevation between high-water mark in the Mississippi and at the Indian Village is 20.2 feet. At Butte á la Rose the difference between high and low water is 6.57 feet; at the second flat it is 8.83 feet; and at the bridge is 7.9.

Now, if we propose taking this bayou route, and making it the navigable channel of communication through to Red River, it will be necessary to lock the Plaquemine near its head, dredge out its lower end, widen Grand River through the narrows, and to remove the obstructions from the Atchafalaya. If, at the same time, we remove the rafts and other obstructions from the net-work of connecting bayous, it will open that entire section of country to navigation.

As the total lift, at extreme stage, to be overcome is 28.8 feet, we will have to use two locks, each having a lift of 14.4 feet. The locks proposed will be 250 feet long and 48 feet between walls of chambers.

The estimates for these locks, made by Mr. Max E. Schmidt, assistant engineer, and appended, are	$199,951 36
Dredging and excavating in bayou is	124,612 84
Dredging and excavating in Grand River is	42,700 46
Protection of bank of Mississippi, 5,000 feet, at $18	90,000 00
Building dam in Old River	96,734 50
Total cost of Plaquemine route	553,999 16

As before stated that Red River being below the Mississippi the plane of its slope has a less inclination than that of the Mississippi, and, consequently, the waters of the latter were forced up the former, and as these waters had no natural outlet other than the Atchafalaya, they would necessarily be backed up the tributary streams. During the extreme high stage of water in the Mississippi we find this backwater extending to the Falls of Alexandria on the Red, and to Ouachita City at mouth of Bayou Bartholomew on the Ouachita, and also up the Tensas and Little rivers, to the great damage of the lands along those streams.

Now, by the adoption of the above plan we secure permanent low-water navigation at all seasons to the trade, commerce, and products of the Red and the Atchafalaya rivers and the Attakapas country, and at the same time secure the lands lying on the different streams from danger from overflow from the backwater due to floods in the Mississippi. The navigation at low-water in the lower reaches of Red River will also be greatly improved.

If, in the plan for the Plaquemine route, we omit the dam in Old River, we can use the lock during the low stage of water (as Old River navigation will then be interrupted), and use Old River during the higher stages, which at the same time becomes an outlet for the waste water from the Mississippi. During this higher stage the gates in the lock at Plaquemine being closed, places that locality in the same condition as at

present. The records of the stage of water show that, for the past eight years, there has been an average of 150 days a year when the water was less than 12 feet in the river at Baton Rouge, above Plaquemine, and the results may be applied to that place also. During such a length of time the boats could pass through without the trouble of locking. The objections to this plan are, that without the dam the condition of affairs along the tributary streams would be as at present—liable to overflow from Mississippi floods. The steamboat interest would, no doubt, prefer the latter plan; that is, so far as the Plaquemine route is concerned.

PLAN RECOMMENDED.

As the mouth of Red River is now only navigable for a limited portion of the season, that is, during the high and medium stages of the Mississippi, except when we resort to dredging, and as this latter is only a *temporary* means of improvement, I would recommend for the *permanent* improvement of the channel the adoption of the Plaquemine route, which includes the protection of the bank of the Mississippi at Plaquemine, the construction of the lock, the improvement of Grand River, and the closing up of Old River. The estimated cost of the improvement is $553,999.16, or, if we omit the dam in Old River and leave that channel open as an outlet and as a navigable route at high and medium stages, the estimated cost of the improvement will be $457,264.66.

In the arrangement for the lock at Plaquemine there will be some trouble arising from the deposition of sediment at the head, so that arrangements must be made for receiving the deposit and for the maintenance and repairs of the works.

The total lift at extreme stages of water is 28.8 feet, to overcome which we must use two locks, each having a lift of 14.4 feet; the bottom of both locks to be 6 feet below the low-water of the Mississippi; the length of each lock between gates, 250 feet; the width of gate walls, 48 feet; the side or chamber walls between each set of gates to be constructed of earth, the banks sloping 1½ to 1, and leaving a channel way 48 feet wide and 6 feet deep at low-water; the height of upper gate, middle gate, and connecting walls, 35½ feet, and of the lower gate and connecting walls 21½ feet, above the bottom of locks; the rise of the miter-sill 9 feet, and the breadth of gate-wing 30 feet.

To the pressure of the water the upper and middle gates each present a surface of 2,028 square feet, and the lower gate 1,194 square feet. The highest pressure per running foot for the upper and middle gates is 23,326 pounds, and for the lower gate 11,250 pounds. The location of center of pressure of the upper and middle gates is 13.73 feet, and of the lower gate 7.07 feet, above the bottom of locks. The moment of overturning force in the upper and middle gates is, for each, 320,265 pounds, and for the lower gate 79,539 pounds.

Thickness of walls.—The vertical faces will front toward the chamber, and battering or stepping faces toward the ground; the walls to be constructed of rubble masonry, the width on top to be 4½ feet, and on the bottom, at the upper and middle gates, 25 feet, and at the lower gate 16⅝ feet; the foundation, as far as the masonry extends above and below each gate, to be composed of a uniform layer of cement-concrete 5 feet thick for the upper and middle gates, and 4½ feet thick for the lower gate; the miter-sill, socket-stone, and the hollow quoin to be composed of dressed stone; buttresses 10 feet thick and 40 feet deep, commencing at the hollow quoin, to extend back at right angles to the axis of the lock 50 feet for the upper and middle gates and 40 feet for the

lower gate; the gates to be of the type known as folding gates; to be constructed of yellow pine and oak; to have three wickets for each wing, to be moved by crabs placed on top of the gate walls.

DETAILED ESTIMATES.

First plan.

	Willows.	Stone.	Piling.
	Cords.	*Cubic yds.*	*Linear ft.*
I. For closing Lower Old River	9,494.19	12,668.96	....
II. For closing Middle Chute	605.05	854.82	....
III. For closing slough	949.46	1,288.99	....
IV. For closing pocket	4,111.87	5,414.81	....
V. For closing Upper Old River	5,133.97	6,838.14	....
VI. For piling	.....	....	17,569
Total	20,294.54	27,065.72	17,569

Cost of works constructed according to the preceding estimates:

20,294.54 cords of willow, at $2.30 per cord	$46,677 44
27,065.72 cubic yards stone, at $3.50 per yard	94,730 02
17,569 linear feet of piling, at 10 cents per foot	1,756 90
To sharpening 500 piles, at 5 cents per pile	25 00
To driving 500 piles, at 90 cents per pile	450 00
Dredging 842,072 cubic yards, at 15 cents per yard	126,310 80
Excavating 393,234 cubic yards (cut to Mississippi River), at 15 cents per yard	58,985 10
	328,935 26
Add 10 per cent. contingencies	32,893 53
Total cost of first plan	361,828 79

Second plan.

New dredge-boat	$40,000 00
Cost of operating two dredge-boats per season	15,000 00

Plaquemine route.

Dredging and excavating in bayou:

Dredging 126,609 cubic yards, at 15 cents per yard	$18,991 35
Excavating 595,287 cubic yards, at 15 cents per yard	89,293 05
Pulling snags and stumps	5,000 00
Add 10 per cent. contingencies	11,328 44
Total	124,612 84

Dredging and clearing Grand River:

Dredging 244,444 cubic yards, at 15 cents per yard	36,666 60
Grubbing and clearing 15.2 acres, at $10 per acre	152 00
Extracting snags and stumps	2,000 00
Add 10 per cent. contingencies	3,881 86
Total	42,700 46

Dam in Old River:

16,493.67 cubic yards stone, at $3.50 per yard	57,727 84
12,326.18 cords willows, at $2.30 per cord	28,350 21
11,640 linear feet piling, at 16 cents per foot	1,862 40
Add 10 per cent. contingencies	8,794 05
Total	96,734 50

Locks:

The estimated cost of upper gate is as follows:

Foundations 5 feet thick over entire lock-pit, 1,511 cubic yards concrete, at $8 per yard	$12,088 00
Rubble masonry for chamber walls, 3,384 cubic yards, at $6 per yard	20,304 00
Dressed stone for hollow quoin and miter-sill, 100 cubic yards, at $18 per yard	1,800 00
Buttresses, extending 50 feet back of hollow quoins, 1,482 cubic yards of concrete, at $8 per yard	11,856 00
Gates:	
Each wing, 13,750 feet—total, 27,500 feet (board measure) of yellow pine, at $30 per 1,000 feet	825 00
Each wing, 3,042 feet—total, 6,084 feet (board measure) of white oak, at $35 per 1,000 feet	212 94
For anchor-iron, strap and angle iron, bolts, nuts, washers, and 2 heel-posts and sockets, 4,500 pounds, at 11 cents per pound	495 00
For 6 cast-iron wickets and fastenings (each 380 pounds), 2,280 pounds, at 10 cents per pound	228 00
Machinery for working gates, including crabs, chains, sheaves, cast-iron rollers, and rails	500 00
Two cast-iron scouring sluices, at $45	90 00
Total	48,398 94

The construction of the middle gate being similar in every respect to the upper gate, its estimated cost is the same.

The estimated cost of lower gate is as follows:

Foundation 4½ feet thick over entire lock-pit, 1,078 cubic yards of concrete, at $8 per yard	$8,624 00
Rubble masonry for chamber-walls, 1,200 cubic yards, at $6 per yard	7,200 00
Dressed stone for hollow quoin and miter-sill, 90 cubic yards, at $18 per yard	1,620 00
Buttresses extending 40 feet back of hollow quoins, 1,185 cubic yards of concrete, at $8 per yard	9,480 00
Gates:	
Each wing, 8,250 feet—total, 16,500 feet (board measure) of yellow pine, at $30 per 1,000 feet	495 00
Each wing, 1,791 feet—total, 3,582 feet (board measure) of white oak, at $35 per 1,000 feet	125 37
For anchor-iron, strap and angle iron, bolts, nuts, washers, and 2 heel-posts and sockets, 3,000 pounds, at 11 cents per pound	330 00
For 6 cast-iron wickets and fastenings (each 350 pounds) 2,100 pounds, at 10 cents per pound	210 00
Machinery for working gates, including crabs, chains, sheaves, cast-iron rollers, and rails	450 00
Two cast-iron scouring sluices, at $45	90 00
Total	28,624 37

Earth excavation and auxiliary work.

Earth excavation is as follows:

	Cubic yards.	
At upper gate	8,088	
Between upper and middle gates	16,910	
At middle gate	9,955	
Between middle and lower gates	22,357	
At lower gate	9,038	
For buttresses	4,149	
Total amount of excavation	70,497 at 50 cents per yard	$35,248 50
For 1,100 linear feet of coffer-dam, at $12 per linear foot		13,200 00

RÉSUMÉ.

Two lock-gates, at $48,398.94	$96,797 88
One lock gate	28,624 37
Earth excavation, 70,497 cubic yards, at 50 cents per yard	35,248 50
Coffer-dam, 1,100 linear feet, at $12 per linear foot	13,200 00
Add 15 per cent. contingencies	26,080 61
Total cost of locks	199,951 36

RECAPITULATION.

Dredging and excavating in bayou	$124,612 84
Dredging and clearing Grand River	42,700 46
Protection of bank of Mississippi, 5,000 feet, at $18	90,000 00
Building dam in Old River	96,734 50
Two locks	199,951 36
Total cost of Plaquemine route	553,999 16

There are forwarded herewith the following maps and drawings pertaining to the survey and workof improvement. The detailed drawings of the lock at Plaquemine are being made, and will be forwarded at the earliest possible moment:

Map of the mouth of Red River and vicinity, from survey of 1878-'79.
Three maps of the mouth of Red River and vicinity, viz:
A. From the survey of 1805.
B. From the survey of 1839, by Dunbar.
C. Showing changes from 1831 (completion of Shreve's Cut-off) to 1866.
* Map of survey of Upper Grand River and Bayous Plaquemine and Jacob (1879), in four parts.
* Map of lower part of Upper Grand River, from the head of the narrows to the foot of Bayou Plaquemine, on an enlarged scale.
* Longitudinal profile of Old River, and Straight, Middle, and Sugar-House chutes.
* Longitudinal profile of Upper Grand River, and Bayous Plaquemine and Jacob.
* Cross-sections of Red River in the vicinity of the mouth, sections 1-X and 1-18; also, sections of Atchafalaya River, Nos. 1 and 2.
* Detail drawing of dam at the head of Turnbull's Island.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 4.

REMOVING OBSTRUCTIONS FROM RED RIVER, LOUISIANA.

Operations were carried on with the snag-boat O. G. Wagner, which entered Red River from the Ouachita in the latter part of July and continued active work until February of this year.

Comparatively little work was done below the falls of Alexandria, as it was deemed advisable to get the boat above that obstruction before the water became too low. Up to the falls 43 snags were removed, and 37 trees cut.

* These maps are not submitted herewith.

After getting above Alexandria the work was continuous, and each of the places named below was worked as thoroughly as possible:

	Snags removed.
Colfax Bar and Cane River	43
Hide Shoal above Montgomery	23
O. K. Bend	77
Prudehomme Bend	99
Tucker's Reach	32
Grand Ecore Bar	26
Rock River Bend	27
Gladiola Bend	144
Closo Bend	94
Rosa Bar	51
Graff's Bluff	52
From the river at intermediate points	712
Total number of snags removed in Red River	1,380
Total number of trees cut in Red River	495

Wrecks of barge at Closo Point and of steamer Glide below Campte, being the only two obstructions of that character in the channel as far up as the boat worked (Merrill's Reach), were also removed.

As Red River reached a lower stage than was ever known before, and thereby afforded facilities for a party to work along the bed of the stream and remove the obstructions by cutting and sawing operations, I sent a party from Shreveport under charge of George R. Wilson, assistant engineer, to work down stream towards the *Wagner*. This party commenced work in October, using a portion of the plant belonging to the old raft appropriation, and continued down the river for upwards of 60 miles to what is known as the narrow river, and to within about 10 miles of the point reached by the snag-boat.

The banks on both sides of the river for this distance were cleared of leaning timber, and all projecting snags were cut off or removed. The water becoming too high for effectual work with this party, about the middle of December operations were suspended and the force withdrawn.

During the coming season it is proposed to repair the snag-boats and place one of them in the river, and with the new appropriation of $60,000 to build a light-draught boat with special reference to work in Red River.

As the work must necessarily be continuous, new obstructions being added each year, it is intended to apply the appropriation asked for, for the fiscal year ending June, 1882, to the operations of the snag-boat, the estimated cost of which for eight months' work, including incidental expenses for repairs, &c., is $24,000.

The former appropriations are as follows:

By act approved June 18, 1878	$25,000
By act approved March 3, 1879	22,500
By act approved June 14, 1880, including cost of new snag-boat	60,000

COMMERCIAL STATISTICS.

Red River is navigated mostly by the steamers belonging to the New Orleans and Red River Transportation Company.

The amount of freight carried during the fiscal year ending June 30, 1880, is as follows:

Bales of cotton	129,000
Sacks of cotton-seed (estimated)	170,000
Head of cattle (estimated)	19,000
Sacks of oil-cake (estimated)	24,000
Sacks of oil-meal (estimated)	4,000
Barrels of cotton-seed oil (estimated)	4,300

There is also transported a large quantity of sugar and molasses from the lower Red River parishes.

It is estimated that at least 75,000 more bales of cotton would have been brought out of Red River had there been good navigation all the season.

During the cotton season the company send out from New Orleans six steamboats per week, which carry on an average 1,200 tons each trip of general merchandise to the Red River country and Texas.

It is estimated that this up-freight has been fully a fourth, if not a third, greater this season than for several seasons past, owing to the general revival of business and the good prices realized for crops. The above works are situated in the third collection district of Louisiana. The port of entry is New Orleans.

Money statement.

July 1, 1879, amount available	$24,401 01	
Amount appropriated by act approved June 14, 1880	60,000 00	
		$84,401 01
July 1, 1880, amount expended during fiscal year		24,401 01
July 1, 1880, amount available		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		24,000 00

O 5.

IMPROVEMENT OF UPPER RED RIVER FROM FULTON TO THE HEAD OF THE RAFT.

The improvement of this section of the river consists in removing the snags, logs, and other obstructions from the bed and banks of the river. Work was commenced at Fulton, Ark., in September, 1879, witn a working force in charge of R. P. Lowe, jr., assistant engineer, and with a portion of the plant belonging to the old raft appropriation.

The following amount of work was accomplished during the working season:

Month.	Snags destroyed.	Average dimensions.	Drift-logs destroyd.	Average dimensions.	Trees felled.	Average dimensions.	Trees girdled.
September	196	2. 0 by 28	755	1. 5 by 60	320	1. 4 by 60	74
October	872	2. 0 by 34	1, 058	1. 8 by 54	354	2. 1 by 68	253
November	142	1. 7 by 38	264	1. 7 by 53	79	2. 0 by 60	76
December	......	..	152	1. 7 by 50	.	......	.....
Total	1, 210	1 9 by 30	2, 229	1. 7 by 55	753	1. 9 by 63	403

Of the 2,229 drift-logs destroyed, 262 of them were taken from the drift above the bridge at Fulton, along with a large quantity of small drift, making a channel 100 feet wide diagonally through the dritt, and also a channel 75 feet wide between the drift and left bank.

Directly in front of the railroad bridge at Fulton a vast amount of drift had accumulated, so completely blocking up the two draw passages that it was impossible for boats to pass. A passage 100 feet wide was cut through this drift pile so that a boat could pass the north draw passage. It was not deemed necessary nor expedient to cut out the entire mass, as when the new bridge at Fulton is completed the old bridge and the drift pile will be removed.

With the balance of the appropriation of March 3, 1879, and that of June, 14, 1880, it is proposed to continue the work. With this amount

I consider that we can remove all the obstructions and place this section of the river in a good navigable condition when there is sufficient water for the boats to run.

The estimated cost of this improvement was $19,560.

The appropriations are as follows:

By act approved March 3, 1879	$10,000
By act approved June 14, 1880	10,000

COMMERCIAL STATISTICS.

It is estimated that about 9,000 bales of cotton are shipped annually from this section of the river, to which should be added a corresponding amount of return freight, consisting of merchandise, supplies, farming implements, &c.

For port of entry and collection district, see report for removing raft in Red River and closing Tone's Bayou, Louisiana.

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$20,000 00
July 1, 1880, amount expended during fiscal year		5,776 34
July 1, 1880, amount available		14,223 66

O 6.

IMPROVEMENT OF THE OUACHITA RIVER, ARKANSAS AND LOUISIANA.

The snag-boat Wagner was repaired in New Orleans and left that port on June 3 for the Ouachita River. The stage of water above Monroe being too low to admit of operations being carried on successfully, work was commenced at that point and continued down stream. The principal work was done at Hopewell Bar, Esperance Bend, Rutland Bar, and Bayou Louis. Four hundred snags were removed and 47 leaning trees cut down. The lower part of the river being in a good condition so far as snags were concerned, the Wagner was transferred to Red River for a season's work.

Attention has heretofore been called to an important improvement needed on the Lower Ouachita, viz, the rebuilding of the dams at Catahoula Shoals. If this work were executed, navigation would be insured to Columbia throughout the entire year.

For the purpose of presenting a plan with estimates for the above improvement, I directed Mr. W. C. Melvin, assistant engineer, after the completion of the survey at Natchez and Vidalia, to proceed to the Ouachita and make a survey of Catahoula Shoals. His report thereon will be found annexed.

The survey shows the existence of three shoals at the locality which form the obstruction known as Catahoula Shoals; and which I have designated respectively as shoal 1, 2, and 3.

For the improvement of shoal No. 1, the State engineers at one time constructed a dam so as to confine the water in a single channel near the right bank. This dam is now partially destroyed, and it is proposed to repair and rebuild it, closing up the above channel and allow for a passage-way through the middle of the structure. This channel-way is the one now used, the river having broken through the old dam at that point, and it seems to be the natural channel.

At shoal No. 2, the improvement will consist in removing some few snags from the channel, in protecting the left bank, and in building a dike so as to concentrate the water in a single channel.

At shoal No. 3, and below, it is only necessary to employ the snag-boat to remove snags and sunken logs, which extend from the head of the shoal to a point some 1,000 yards below.

The estimated cost of the improvement at shoals 1 and 2 is $29,934.20. The dikes will be built of stone, sufficient quantities of which can be procured at the locality.

During the coming season it is intended to employ the snag-boat in continuing the removal of the obstructions in the river and in carrying on the above mentioned improvement.

The appropriation asked for for the fiscal year ending June 30, 1882, will be expended in continuing the work as heretofore with the snag-boats and continuing the work at Catahoula Shoals.

No detailed estimates will be presented for the improvement of the Ouachita with the snag-boat, since the nature of the work must be continuous from year to year, owing to the character of the obstructions which each flood brings down.

Amount appropriated March 3, 1871	$51,000
Amount appropriated June 10, 1872	100,000
Amount appropriated March 3, 1873	60,000
Amount appropriated August 14, 1876	12,000
Amount appropriated June 18, 1878	10,000
Amount appropriated March 3, 1879	10,000
Amount appropriated June 14, 1880	8,000

The first appropriations were made with a view to the improvement of the river by means of a system of locks and dams, the estimated cost of which was $1,163,083.75, and by operating with a non-propelling crane-boat.

A portion of the funds appropriated had been expended under this project for material, surveys, &c., when it was abandoned, and the balance of the funds was expended in the purchase of an iron-hull snag-boat and in operating it upon the river.

COMMERCIAL STATISTICS.

From September 1, 1879, to June 24, 1880, the following vessels navigated the Ouachita River.

Names of vessels.	Tonnage.	Number of trips.	Number of bales of cotton carried.
Fred. A. Blanks	810	16	30,372
John H. Hanna	377	18	18,313
John Wilson	297	20	17,417
John Howard	485	10	13,373
Corona	338	6	10,897
William Fagan	225	9	9,426
D. Stein	....	1	634
Saint John	....	1	669
Saint Mary	....	9	1,082
Tom Perkins	....	11	2,238
Little Bob B	....	1	327
Big Sunflower	....	3	1,949
Era No. 10	....	11	5,425
Tensas	....	15	4,592
Clara S.	....	9	7,491
Katie P. Kountz	....	3	2,771
General Tompkins	....	1	160
Gen. D. H. Rucker	....	1	1,016
Red Cloud	....	1	555
Total	....	....	128,707

In addition to this, there is a large quantity of miscellaneous down-freight, consisting of sacks of cotton-seed, head of cattle, white-oak staves, &c.

The value of up-freight, consisting of general merchandise, provisions, &c., is estimated at about $4,000,000.

The Ouachita is in the collection district of Arkansas, there being but one, and in the third collection district of Louisiana.

Money statement.

July 1, 1879, amount available	$14,148 14	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$22,148 14
July 1, 1880, amount expended during fiscal year		8,017 30
July 1, 1880, amount available		$14,130 84
Amount (estimated) required for completion of existing project Catahoula Shoals		$20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882 at Catahoula Shoals and expenses of snagboat		35,000 00

REPORT OF MR. W. C. MELVIN, ASSISTANT ENGINEER.

CATAHOULA SHOALS, *November* 11, 1879.

MAJOR: I left Vidalia on the 23d of October, 1879, on the steamer Natchez, with four men and camp outfit, to make an examination of the Catahoula Shoals and vicinity, on the Ouachita River. At the mouth of Red River I reshipped on the small steamboat Little Bob B., and did not reach the shoals until the morning of the 27th.

An examination of the shoals, commencing above Little Creek and ending below Harrisonburg, at the gravel shoal at the mouth of Tolefero Bayou, discloses a number of difficult places that will be treated as they occur, commencing at the upper shoal.

In the bend of the river above Big Creek is found an extensive gravel bar, with large rocks scattered over it that appear to be the remaining parts of a continuous layer through which Little Creek has worn a channel to the river. The south bank of Little Creek and the east bank of the river is a high, rocky bluff, and the rocks, crumbling and falling in the water, have formed a strong stone revetment, protecting the bank for several hundred yards below the mouth of Little Creek. Near the mouth of Little Creek the bluffs approach very close to the water-line; the falling stones often roll into the bed of the river, forming a rocky shoal extending from shore to shore. These obstructions cover about 120 yards down from the point of beginning, the depth of water over them being 3 feet and more between the rocks. Nearly all of these rocks are under the surface of the water, and more dangerous from the uncertainty of their location.

From this point to the head of the dam there is a good depth of water, running through a clear channel to the artificial spur or breakwater protecting the head of the dam.

On the shoal is a channel 50 feet wide, averaging 27 inches deep, and very swift; thence to the foot of the shoal is a varying depth of from 2 to 3 feet. In the passage through the break in the dam there is 2 feet of water for a width of 34 feet, the break itself being 116 feet, the width of water 106 feet.

Through the old channel around the foot of the dam the water depth varies from 2 feet to 22 inches in depth, the greatest depth being but a few feet from the shore. Below the foot of the dam the water shoals to 14 inches, spreading out fan-like from the point of the island to the right bank.

The removal of some snags nearly opposite the foot of the dam on the left bank, some of them now out of water, others under its surface, will make this water-route much better than one on the right shore, it now having a depth of 3½ feet all the way below the head reef at the break. On the right shore the shoal water extends down nearly half a mile; on the left it commences to deepen immediately below the head reef, and but for the snags before mentioned would not offer any obstruction to a craft that could cross the head reef.

The dam itself, formed of a zigzag line of loose stones extending from the left shore down until it approaches a point 141 feet from the right bank, is about 2 feet above the present water-surface, with a gravel bar formed on both sides of it rising to within a few inches of the top. The dam near its upper end, for about 250 feet, seems to have been broken away in several places and the stones scattered below the original position; between this line and the left shore is formed a bar of gravel considerably

higher than the stone-work of the dam. On this bar are scattering piles of rock, placed there by accident or intention, which have formed a very efficient support to the main line of breakwater.

The spur-dike, 250 feet above the head of the dam, remains intact and is now about 100 feet below the head of the gravel bar formed on the outside of the dam, and here the surface line of water between the right shore and bar is reduced to a width of 76 feet and a greatest depth of 33 inches, and rapid flow

From what has been said and an examination of the chart, sheets 1 and 2, you will comprehend the situation of the upper shoal. I may here mention that a line of the same kind of stone breakwater, running from the lower side of the break and extending to the right or west bank at a right angle from the line above it, will much improve the pass through the dam and make a permanent low-water channel down the left shore. In addition to this extension to the old dam, the line should be strengthened and raised about 2 feet, and strong pier-heads or revetments should be built on both sides of the water-way through the dam, extending below for 40 feet.

The removal of sunken rocks at the mouth of Little Creek, the extension of the dam, about 350 feet of new line and repairs to the old line above the break, the removal of 15 or 16 snags from the channel at and a short distance below the foot of the present dam near east bank, will effect all that can be done to improve this shoal No. 1. It will be noticed that all the water passing down at the present stage of the river passes through a channel-way 76 feet wide and a greatest depth of 33 inches; average depth of 26 inches, entire cross-section of 158 feet.

The channel-way through the dam will be 50 feet at bottom, 71.2 at the top; section, 321 feet; velocity of current November 1, 1879, was 6.2 feet per second.

The volume of water that can be utilized with the water at equal stage with November 1, 1879, is from the south chute (the original channel), discharging section of which is 85 feet, and a velocity 5.8 feet per second.

Through the break in the dam, now the main channel, the section is 212 feet, velocity 6.2 per second; by closing the south chute and confining the water to a single channel with a mean width 60 feet, allowing for increased velocity and other waste, we can depend on a 4-foot depth of water with the same quantity of water that was found during the time of the survey of the shoals in November, 1879. It is seldom that the water recedes to this low point. A gentleman who has resided in this vicinity many years informs me that the stream was at its lowest point about the 26th of October, that "he had not seen it so low any time before in his recollection." On my gauge put up on the 26th October it had receded nearly 0.3 on the 1st of November, and this I assume to be the low-water of 1879.

The south wing of dam No. 1, extending from south bank at an angle of 60 degrees from shore line and bearing downstream, will be 342 feet long, having a mean height of 5.3, mean width of base 25.2, crown 4 feet, and will require for its construction 11,007 cubic yards of stone.

The north wing of dam, having a length of 857 feet, a mean height 3.92, a mean base of 19.34, crown 4 feet, will require 1,576 cubic yards of stone.

For the revetment of north bank between head of dam and the upper spur-dike, 224 feet long, 150 cubic yards of stone will be needed.

From the foot of this shoal, No. 1, to the head of No. 2, mouth of Bayou Louis, is a depth of water not less than 5 feet, in places reaching a depth of 19 feet.

From the head of shoal No. 2 the most of the trouble comes from snags, many of them now exposed, but many more of them out of sight under water. The pass at the head of the shoal is 92 feet wide, the greatest depth of water through it is 27 inches; this depth continues for about 30 feet, then deepens near the east bank to 3½ and 4 feet, and but for the snags in the channel would not seriously interfere with the passage of small steamboats, provided they have sufficient power to stem the swift current that runs here for nearly 1 mile. Since I commenced examinations of the channel, I find it has changed from the beginning of the second half mile below the head of shoals, and is cutting away the sand-bars on the west shore, and where I then did not find water sufficient for the passage of my large skiff, I now find 3 feet of water; this depth of water, however, cannot be relied on, for every hard rain will fill it up again by washings from shore. The channel on the east shore will maintain itself, and a snag-boat would help it very much if used during low-water, for with 5 feet more water in the river it could not be successfully used, as many of the logs will then be covered with mud and sand.

If a project for lock dams be entertained, this shoal is the only place where any good effect can be found in their use, and I think the result of constructing works of that kind is of doubtful utility; the many objections to placing works of that kind in positions where they must be altogether under water 8 months out of the 12 of every year must be evident enough.

A system of spur dikes-projecting from the west bank at an angle of 60 degrees from the shore line and extending to within 100 feet of the east bank, forcing the water through it, would be economical and easy of construction. The material (stone) for the

work can be procured from the cliffs on Sicily Islands, at the upper shoal, about 1½ miles above the place where they are used.

A dam below the mouth of Bayou Louis will require in the construction of both wings 1,977 cubic yards of stone; the dam will consist of a south wing extending from south shore line, and bearing 75 degrees from it down the stream, and a revetting wall and a confining wall 215 feet in length.

About the lower shoal, No. 3, below the mouth of Talefero Bayou, not much need be said. There is no trouble at the shoals, but immediately below them trouble is found with sunken snags. These extend down about 1,000 yards, the channel much clogged and very crooked. A snag-boat is the only thing that can do much good here. A ledge of rocks commencing 120 feet from the east bank, running down towards the mouth of Talefero Bayou, seems to have been constructed with a view of forcing the channel along the west shore, without success, for a clear deep channel runs down the east shore and a gravel-bar closes the mouth of the bayou.

I will close operations here in two or three days.

River has commenced rising. Last night and to-day it has risen 5 inches above the lowest water of the season. There is now 2½ feet on the bar at the head of No. 2.

ESTIMATES.

The cost of quarrying and delivering the first 1,000 cubic yards of stone at a point convenient for loading in barges:

825 days' labor, at $1.25 per day	$1,031 25
825 days' subsistence, at 45 cents per day	371 25
20 wheelbarrows, at $4.50 each	90 00
50 crowbars and picks	112 50
Timber, bolts, nails, labor, &c., for chutes	300 00
Shovels	45 00
	1,950 00
Cost of loading in barges and putting in position in the dam, assuming 16 cubic feet to be the average day's work for one man:	
Wages and subsistence, $1.70 per day	2,868 75
Cost for first 1,000 cubic yards	4,818 75
Amount of cubic yards in No. 1, 2,833:	
To place 2,833 cubic yards in position, at $4.82 per cubic yard	13,655 06
Amount of cubic yards in No. 2, 1,977:	
To place 1,977 cubic yards in position, at $4 82 per cubic yard	9,529 14
Total cost of stone in place	23,184 20

To which must be added the cost of barges, superintendence, transportation, and other expenses incidental to a work of this kind.

Five barges with a capacity for carrying 20 cubic yards of stone each, with suitable tackle and other apparel, at $450 each	$2,250 00
For other items as named above	4,500 00
Total	6,750 00

RECAPITULATION.

Cost of stone laid in Dam No. 1	$13,655 06
Cost of stone laid in Dam No. 2	9,529 14
Cost of barges	2,250 00
Cost of other items as above	4,500 00
Total for Nos. 1 and 2	29,934 20

There are in addition to the dam work 100 or more snags lying in the channel between the upper shoal and Bushley Bayou, one-half mile below the town of Harrisonburg.

Above the shoals, at the mouth of Little Creek, are a number of rocks that have fallen from the cliff and rolled into the channel. A snag-boat could easily remove them.

Very respectfully,

W. C. MELVIN,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 7.

IMPROVEMENT OF YAZOO RIVER, MISSISSIPPI.

Upon the completion of the snagboat John R. Meigs, she was sent into the Yazoo for a short season's work for the purpose of removing snags, logs, and other obstructions to the stream.

The wrecks of the steamers Star of the West and Mary E. Keene were first removed, and work then commenced on the snags, logs, &c., and continued until January 18, 1880, when the water became too high to prosecute the work favorably. A rack heap at the mouth of Tchula Lake was also pulled out, and a number of leaning trees cut down, making a total of 2,723 cuts made.

With the appropriation of June 14, 1880, it is proposed to continue operations this coming season in removing snags and other obstructions; for that purpose one of the light-draught snagboats will be put in the river.

The appropriation asked for, for the year ending June 30, 1882, will be expended in the same way.

ESTIMATE.

Eight months' expenses of snagboat, including incidental repairs, at $2,500 per month	$20,000

The former appropriations are as follows:

By act approved March 3, 1873	$40,000
(This amount was applied to the removal of eleven wrecks sunk in the stream during the operations of the war.)	
By act approved March 3, 1875	12,000
By act approved August 14, 1876	15,000
By act approved June 18, 1878	25,000
By act approved March 3, 1879	15,000
By act approved June 14, 1880	12,000

COMMERCIAL STATISTICS.

The Yazoo and its tributaries are navigated by the steamers belonging to the Mississippi and Yazoo River Packet Company, and by a few independent steamers, and the amount of freight transported during the last fiscal year is as follows: 95,135 bales of cotton, 125,000 sacks of cotton-seed, to which should be added a corresponding amount in value of return freight, consisting of plantation supplies and general merchandise.

Yazoo River is in the collection district of Vicksburg, Miss. The port of entry is New Orleans, La.

Money statement.

July 1, 1879, amount available	$22,359 66	
Amount appropriated by act approved June 14, 1880	12,000 00	
		$34,359 66
July 1, 1880, amount expended during fiscal year		22,359 66
July 1, 1880, amount available		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

O 8.

IMPROVEMENT OF WHITE AND SAINT FRANCIS RIVERS, ARKANSAS.

The snag-boat John R. Meigs, intended for these and other rivers, was finished in October, 1879, and left Saint Louis on the 21st of the same month. She was first put into the Yazoo for a short season's work. In January she was withdrawn from the Yazoo and put into the White River. It being late in the season the river was above its average stage, and consequently the work of removing obstructions was attended with more difficulties and uncertainties than if the water had been at a lower stage.

The *Meigs* worked up as high as Jacksonport, which is considered the head of navigation for large boats, removing such obstructions as were in the way.

For work on the Saint Francis I chartered the steamer General Miles and barge, had the same fitted up, and commenced operations November 27, and continued until January 30, 1880. Work was started at Madison, and continued up as high as the mouth of Little River, with the following results:

Trees cut down	1,151
Snags removed	130
Rock heaps destroyed	11
Trees lying along the shore cut up	50

During the coming season it is proposed to continue operations in the White and Saint Francis with the snagboats, removing the obstructions, the running expenses of which for ten months, including incidental repairs, &c., is estimated at $20,000.

With the appropriation asked for for the fiscal year ending June 30, 1882, it is proposed to continue the work of removing obstructions from the river with the snagboats.

The former appropriations are as follows:

Allotted from appropriation for contingencies of rivers and harbors (act approved July 11, 1878), for the improvement of White River	$10,000
Act approved March 3, 1871, for the improvement of Saint Francis River, in Arkansas	10,000
Act approved March 3, 1873, for the improvement of White and Saint Francis rivers	50,000
Act approved June 18, 1878	40,000
Act approved March 3, 1879	12,000
Act approved June 14, 1880	12,000

COMMERCIAL STATISTICS.

The cotton annually brought to market at amounts to about 35,000 bales, besides a corresponding amount of return freight.

For collection district and port of entry, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

July 1, 1879, amount available	$14,011 12	
Amount appropriated by act approved June 14, 1880	12,000 00	
		$26,011 12
July 1, 1880, amount expended during fiscal year		14,011 12
July 1, 1880, amount available		12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		20,000 00

O 9.

IMPROVEMENT OF WHITE RIVER, BETWEEN JACKSONPORT AND BUFFALO SHOALS, ARKANSAS.

This improvement was inaugurated at Buffalo Shoals by Major Suter. The plan contemplated at this point, the construction of seven spur dikes of stone, so located as to pond up the water in the places of least depth. At the commencement of last season's work, three of these proposed dikes had been completed, and the project for the expenditure of the appropriation of $10,000, made March 3, 1879, contemplated the construction of the remaining four.

The work at Buffalo Shoals was commenced early in September and finished November 14. The exceedingly low stage of water in White River enabled the operations to be carried on much more ecomonically than had been anticipated, and therefore, having a balance of the appropriation left, projects were submitted to the department, and approved, to continue the work at the shoal places below. Accordingly the force was moved down to Nellie's Apron Shoals, 2 miles below, where a large and dangerous ledge of rocks was blasted out. The force was then transported to the rapids, 20 miles below. Two wing-dams were built at this locality so as to concentrate the water in a single channel. Heavy rains and high water coming on, prevented any further operations for the remainder of the season.

There are other shoals between Buffalo and the rapids that require improving, but the above work was undertaken at the request of the steamboat men as being the worst place in that stretch of the river. They express themselves pleased with the work, as affording them much greater facilities for reaching Buffalo City. The intermediate shoal places did not present sufficient obstacles to call for any considerable amount of work.

A list of the shoal places between Buffalo City and Batesville, with estimates for the improvement of the same, was presented by Major Suter in his report for 1876, as found in Part I of the Report of the Chief of Engineers for that year, page 625. If the improvement be carried out it will greatly facilitate the transportation of the productions of the Upper White River country.

With the appropriation of $5,000, made by act approved June 14, 1880, and with the balance of the old appropriation, it is proposed to continue the improvement by building dikes at Samm's Shoal and Fish Trap Shoal below.

With the appropriation required for the fiscal year ending June 30, 1882, it is intended to continue the improvement of the worst of the shoal places mentioned in the above-named report of Major Suter.

For details of the work executed this season, I beg leave to refer to the report of Mr. J. D. McKown, assistant engineer, who had local charge of the work.

The former appropriations are as follows:

By act approved March 3, 1879	$10,000
By act approved June 14, 1880	5,000

COMMERCIAL STATISTICS.

In Marion County, Arkansas, there was raised about 4,000 bales of cotton, two-thirds of which was shipped by wagon to Springfield, Mo., the remainder by river. Nearly all the merchandise used in this county was taken there by wagon from the

railroad, a distance of about 100 miles. Nearly all if not the whole of this trade would be done by river if it were navigable.

There are also about 5,000 bales of cotton that would be shipped by river from Boone and Searcy counties, Arkansas, and Taney and Ozark counties Mo., besides a surplus of wheat, bacon, and corn that would find its way out by river from these upper counties if justified in doing so.

In Baxter County, Arkansas, about 3,000 bales of cotton were raised, one-half of which was shipped by wagon to the railroad at Marshfield, Mo.

There was about 400 tons of merchandise brought into the county during the season, nearly all of which was by wagon from the railroad. If White River were navigable, all of this trade would be by river.

There was carried by river from Batesville, Ark., to Newport, Ark., during the season of 1879-'80, 15,000 bales of cotton, of which about 2,000 bales were from Buffalo Shoals and above, and 4,000 bales from between Buffalo Shoals and Batesville. The remaining 9,000 bales were transported to Batesville, by wagon, from the counties bordering on and near the river.

For port of entry and collection district, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$15,000 00
July 1, 1880, amount expended during fiscal year		7,786 71
July 1, 1880, amount available		7,213 29
Amount that can be profitably expended in fiscal year ending June 30, 1882, also White River between Jacksonport and Buffalo shoals		20,000 00

REPORT OF MR. J. D. M'KOWN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 20, 1880.

MAJOR: I have the honor to make the following report of work done on White River above Jacksonport, Ark., during the past season:

Pursuant to instructions received from you September 1, 1879, I proceeded to Buffalo Shoals in order to continue the work commenced there in 1878.

I found the condition of the river very low, said to be the lowest water ever known. The old work was found to be in perfect condition, having stood the test of successive rises in the river safely. The new work was commenced soon after my arrival, by building an extension of dam No. 2, which was carried out 120 feet beyond the end of the old dam, the object being to back the water up still more on the shallow ledge above, which was the worst place on the shoals. The work was commenced on September 19, 1879, and completed on October 9. The contents were 200 cubic yards of rock. The crest of the ledge was also taken off by blasting. The result is that now boats can pass in safety when they can run in the upper river at all.

The next work was on dam No. 5, which was commenced on October 6 and completed on October 22. This dam was 180 feet in length and contained 368 cubic yards of rock. The object was to close a chute on the right bank through which about half the water of the river flowed. Almost opposite, a chute was closed the year before, so that at present all the water is thrown together in the middle channel. Another benefit of these dams, and one that was contemplated, is to hold back the water on the shoal above. Naturally the velocity of the current is increased between the islands, and at some stages of water the boats of light power have to pull through with a line. But as the loss of time is comparatively small, and the benefit derived by being able to pass down with a good load so great, that steamboatmen are well pleased with the change.

Dam No. 7, running from the left bank, was commenced on October 13 and finished on November 14. A small force only was at work there. Its length is 105 feet, and contents 131 cubic yards. Work on the dam running from the right bank and nearly opposite was commenced on October 23 and completed on November 13, its length being 201 feet and contents 364 cubic yards of rock. The original plan of this dam was to build it out 300 feet from the right bank, but it was thought advisable, with your approval, to change it as above, in order to give pilots a better chance to handle

their boats in the swift water met with there. It was also more economical, and held the water back as well if not better than on the old plan.

The crest at the head of the shoal was blasted off, also some rock between the crest and the dams. One large rock was blasted out at Buffalo City which had made the river impassable at a low-boating stage.

At Nellie's Apron Shoals, 2 miles below Buffalo Shoals, a very dangerous ledge was taken out, to the great relief of navigation.

On the 21st of November we moved down to the Rapids, 20 miles below Buffalo Shoals. During the early part of the work there the progress made was very rapid, but afterwards the rain and high-water retarded it very much.

Two dams were constructed, one from the right bank to the bar, its length being 230 feet, and containing 179 cubic yards of rock; The other from the bar to the head of the island, 520 feet in length, and containing 910 cubic yards of rock. All the water is thrown in the main channel, so that boats can pass whenever able to reach it.

These dams, like those at Buffalo, are built of rock and on rock foundation, with a width on top of 4 feet, and slope on upper side one to one; on the lower side, two to one.

The improvement of White River is of the greatest importance to the people in the country bordering on the river, which is almost wholly dependent on water transportation. The nearest railroads are the Iron Mountain and Southern, on the south, and the Saint Louis and San Francisco, on the north, leaving a strip of country 230 miles wide by the nearest wagon road between them.

Cotton is the staple product of the country, and it is only within a few years past that it has been extensively raised in the upper country, but is continually growing in favor. No doubt if greater facilities of transportation were afforded an increased acreage would be cultivated.

I would suggest as a means of working the river the construction of two flat-boats that could be fastened together, leaving a space between them, and having a shears with a leg resting on each boat. Then with capstans for power, either rock or snags could be raised out between them. When constructing dams these boats could easily be taken apart and used for the transportation of material to be used in the dam. Such an arrangement would be of light draught and economical, costing, probably, not more than $1,500 complete.

The value of the improvements already made might be enhanced by improving two shoals above Buffalo, viz, Crooked Creek and Redbud Shoals. Both are of rock formation and would require blasting. An examination would be necessary for an estimate, but it would not be a large one, probably not to exceed $2,000 for both places. This would give an outlet to the country above Mountain Home and Yellville. At present boats do not often go above Buffalo when it is possible, as they could not pass the Crooked Creek Shoal 5 miles above.

However it is probably of more importance to continue the improvement from the rapids down the stream, as there are many shoals, both of rock and gravel formation, which could be improved so as to allow boats to pass up the river at a much lower stage of water than is possible with the stream in its present condition.

I have the honor to inclose herewith maps of Buffalo Shoals, Nellie's Apron Shoals, and of the Rapids, showing the improvements made up to the present time.

Very respectfully, your obedient servant,

J. D. McKown,
Assistant Engineer.

Maj. W. H. H. Benyaurd,
Corps of Engineers, U. S. A.

O 10.

IMPROVEMENT OF WHITE RIVER ABOVE BUFFALO SHOALS, ARKANSAS.

An examination of this portion of White River was made in 1871 and 1872, by Mr. Alonzo Livermore, assistant engineer, and under direction of Lieutenant-Colonel Raynolds. The report thereon will be found in the reports of the Chief of Engineers for those years.

The total estimated cost of the improvement was $101,220.

Work on White River has been carried on during the past two years at Buffalo Shoals and below, and in order to make the work in the two sections continuous it is proposed to improve the shoal places immediately above Buffalo.

Before commencing operations, however, it is proposed to make an examination of this immediate locality, and determine more definitely the nature of the obstructions and the best means to improve the same.

For commercial statistics see report for improving White River, Arkansas.

For collection district and port of entry, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

Amount appropriated by act approved June 14, 1880	$20,000 00
July 1, 1880, amount available	20,000 00

O 11.

IMPROVEMENT OF SAINT FRANCIS RIVER BETWEEN WITTSBURG AND LESTER LANDING.

This work is but a continuation of that heretofore carried on upon the Saint Francis, and will consist of the removal of the obstructions to navigation in the shape of snags, logs, leaning timber, &c. For this purpose one of the light-draught boats will be used.

In the act making the appropriation, Wittsburg was put down *Wilkesburg*. As there is no such place on the river I have inserted the proper name.

For commercial statistics, see report for improving White and Saint Francis rivers, Arkansas.

For port of entry and collection district, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00

O 12.

IMPROVEMENT OF L'ANGUILLE RIVER, ARKANSAS.

There being so many demands for the snagboat and the dredgeboat I had intended putting into the L'Anguille and adjoining streams, combined with the appearance of the yellow fever in this section of the country, that I was unable to carry out the project last season for the improvement of the L'Anguille, and I therefore reserved the appropriation for work during the coming season, which will be carried out.

The two appropriations combined will, I believe, be sufficient to place the stream in good navigable condition for several years, and therefore no further appropriation is asked.

The appropriations have been as follows:

By act approved June 18, 1878, expended in building snag-boat	$10,000 00
By act approved March 3, 1879	5,000 00
By act approved June 14, 1880	2,000 00

COMMERCIAL STATISTICS.

There is brought out of the L'Anguille about 2,500 bales of cotton annually, and when the improvement of the river is completed a large quantity that is now shipped

by railroad, and also hauled to the Saint Francis, will be brought out by the steamboats.

Money statement.

July 1, 1879, amount available	$5,084 17	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$7,084 17
July 1, 1880, amount expended during fiscal year		80 15
July 1, 1880, amount available		7,004 02

O 13.

IMPROVEMENT OF BIG SUNFLOWER RIVER, MISSISSIPPI.

It was intended at first to put one of the light-draught snagboats into this river for a season's work, but as the boats were employed on the other streams, and as it was desirable that some work should be done on the Sunflower at an early day, so as to facilitate the early movement of the crops, authority was granted to charter a light-draught steamboat, fully equipped, and operate with her in removing snags, logs, and other obstructions. Accordingly the *Deer Creek* was hired, and operations commenced with her on September 11, 1879, and continued until the end of November.

Surveys were also made of Oliphant's Bar and Mussel Shoals with a view to the improvement of these two places by a system of brush wing dams. These places are the only ones along the river where any construction of such a nature need be attempted. As the water was at a very favorable stage for operations at the time the survey was finished, work upon the wing-dams was immediately commenced.

The effectiveness of the improvement of Oliphant's Bar may be judged from the fact that where formerly but 18 inches of water could be found on the shoals, there is now something like 3 feet. The boats now navigating the Sunflower can go through without interruption, when formerly, during the low stage of water, they were detained several days.

During the coming season it is proposed to continue the removal of snags, &c., and the improvement of Mussel Shoals. The latter will be by a series of brush wing-dams like at Oliphant's Bar, but in addition, as the bottom is composed of a layer or crust of hard material, means will be employed to break up the bottom so as to allow the increased current to carry the material off.

The appropriation asked for for 1882 will be expended in the same way.

Previous to the operations on the river by the government, the Vicksburg and Sunflower Packet Company employed a force in improving the river by removing snags and cutting down the leaning timber. The *Deer Creek* commenced work at the point left off by the Packet Company. James M. Searles, assistant engineer, had charge of the work of improvement and surveys, and the following extracts from his reports will give the nature and extent of the operations:

September 14.—We are now working at the head of Mussel Shoals, 43 miles from the mouth of the river.

September 21.—Up to this date 200 logs and snags, the worst obstructions, have been removed, and the most of them placed in such positions as to form effectual wing-dams. The result of these removals has been an increased current velocity, and a rapid washing away of sandy accumulations. At shoal-water places, where the logs

within the bed of the river were insufficient in number for the building of wing-dams, pecan trees were felled from the bank and dragged into the stream. This timber is found in great abundance immediately along the banks of the river, and as it has the favorable characteristics of heavy specific gravity and umbrageous growth, it is admirably suitable for wing-dam purposes. We are now at the head of Dewberry Island, about 50 miles above the mouth of the river. From this point up, about 25 or 30 miles, navigation is comparatively easy, there being but few logs or snags in the way; from thence throughout the upper reach of the river the worst obstructions are to be found.

September 28.—I have mentioned, in previous reports, the making of wing-dams with trees felled from the bank. These, I have observed, are quite effective in increasing the depth of water where the bed of the river is of soft material or light sand. Such construction is of an open character, admitting the passage through it of too much water, and would be of no utility in hard-bottom places. I would, therefore, respectfully suggest that I be supplied with sawed cypress lumber (8-inch square piling and 2-inch plank) to be used at places where close wing-dams may be required. The piling need not be longer than 8 or 10 feet. It would also be necessary to employ a rake, after constructing the close wing-dams, that the hard bottom might be broken up, and thereby augment the current action on the bed of the stream.

November 5.—The construction of the wing-dams is rapidly and favorably progressing, one already completed and another begun. The finished one measures 132 feet in length. It was built with 16 4 by 4 inch piles, driven from 8 to 10 feet in sand and blue mud with a 100-pound hammer. The sheeting is of 2-inch plank, driven to an average depth of about 6 feet. The steamer Deer Creek, drawing 2¼ feet large, passed up and down by the dam, floating down and passing up without pulling. The original channel-depth was about 18 inches. Should the dam resist heavy scouring (and I do not doubt that it will, as the sheeting extends from 4 to 5 feet below the bed of the sand), it may be that new bars will form at some points in the channel-way below. Should this occur they can be removed by similar means.

November 21.—The work at Oliphant's Bar was completed on last Wednesday, by the building of 10 wing-dams. There is now an average channel-depth of 3 feet.

The steamers Deer Creek and Little P passed from the foot to the head of the bar without putting out a line. I am now at work at Mussel Shoals. The river is still very low, and I hope to deepen the water on the worst places for navigable purposes before the coming of a river rise. As yet there has been no appreciable rise in the river either at this place or at Oliphant's.

The survey of Olipnant's Bar and Mussel Shoals being completed, I have discharged the party on their return to Vicksburg.

If it be your intention to have a complete survey of the river made, I would suggest that you order a continuance of the present survey, inasmuch as the water is now very low, and will probably remain so for six weeks or two months, at least sufficiently so to permit of easy triangulation near the river surface. I think it would be well to have a survey of what is known as the Crooked River, a stretch of about 23 miles, connecting Oliphant's Bar and Mussel Shoals. This work could be done now very conveniently.

December 1.—In fulfillment of your instructions, the work of the steamer was discontinued on the evening of the 27th, and her captain ordered to return her forthwith to Captain Parisot or his agent at Vicksburg.

In reference to the construction of the lumber wing-dams, the shallowness of water-depth at Oliphant's Bar and Mussel Shoals indicated these two places as the very worst obstructions to the navigation of the river, and as the commerce of the country and the extreme necessities of the planting community called for immediate relief, I thought that it could be most speedily and economically given by devoting the time of the low-water season to the improvement of the bar and shoals by close lumber wing-dams.

No more time was expended in their construction than was absolutely necessary to accomplish an effective result. No work of this character could be done at these places, which, serving a temporary purpose, would not produce a radical and permanent improvement of the channel; and this is obvious from the fact that every wing-dam has been strengthened by a heavy accumulation of sand and other material on the down-stream side.

December 30.—In submitting this as a final report on the survey and improvement operations which have been recently conducted on the Sunflower River, I can only add to the several reports which I addressed you from time to time during the progress of the work an earnest recommendation that it be continued during the next low-water season. This recommendation is suggested by a consideration of the absolute improvement which has been effected in the navigation of the stream by the removal of logs and snags (the number being 640 from the date of commencement under your orders) and the building of the wing-dams, the positions of which are shown on the map.

The bed of the river in the Oliphant's Bar reach is of a soft siliceous character, and

is readily cut out by the erection of a wing-dam of the simplest construction. Those made of sawed lumber consisted of 4 by 4 inch piling, driven to depths varying from 6 to 15 feet with a hundred-pound hammer, at distances apart of 8, 10, and 12 feet. The tops of the pile pieces were connected together by a side stringer of 2 by 12 inch plank, secured by 60-penny nails.

The sheeting was placed vertically, being leveled on the top edge to insure close contact, and driven with hand mauls to depths of from 3 to 6 feet below the bed. The tops of the sheeting were nailed to the string pieces. The effectiveness of the work was demonstrated by the Sunflower packet-boats passing over the bar, throughout its entire length, without a single detention and at a time when there was no rise in the river.

Before the construction of these works, steamers were detained on the bar for three or four days. Though the dams are built of light material, they must necessarily serve a permanent purpose, as they now have a sustaining wall on the lower side, formed by the natural accumulations of earthy material. The work of wing-damming Mussel Shoals, which was but begun at the time of discontinuance of work, should be carried on at another favorable low-water season. Three lumber dams were constructed in this shoal, but proved ineffective in cutting out the hard bed. As was suggested in a former report, this work should be supplemented by a raking process that would cut into the bed crust, and thus facilitate the removing power of the wing-dams. The navigation of what is known as the Crooked River, a distance of 18 miles between Silver Creek and Choctaw Landing, can be much improved by the removal of the logs which, during a low-water stage, so seriously obstruct it.

There is so manifest an appreciation on the part of the rivermen and planters along the Sunflower River of the good you have done them within the limited time of your operations, and on my own of the means with which you have at all times so promptly furnished me for the carrying out of your instructions, that I must, in their and my own behalf, give it in this communication most grateful expression.

COMMERCIAL STATISTICS.

During the season the steamer Sunflower, belonging to the Parisot Line, made regular trips in this river, and occasional trips were made by other boats.

The following is the amount of cotton, &c., brought to Vicksburg by these boats: 15,817 bales of cotton; 25,000 sacks cotton-seed. To this should be added a corresponding amount in value of return freight, consisting of plantation supplies and merchandise of all kinds.

The uncertainty of navigation in this stream compels a number of planters on the upper river to haul their cotton to the Mississippi, which otherwise would go down this river, and it is estimated that the shipments will be twice the amount of the present movements when the improvement of the navigation is completed.

The estimated cost of the improvement of this river was $66,000.

The former appropriations are as follows:

By act approved March 3, 1879	$20,000 00
By act approved June 14, 1880	8,000 00

For port of entry and collection district, see report for improving Yazoo River, Mississippi.

Money statement.

July 1, 1879, amount available	$20,000 00	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$28,000 00
July 1, 1880, amount expended during fiscal year		9,611 68
July 1, 1880, amount available		18,388 32
Amount (estimated) required for completion of existing project		38,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		10,000 00

O 14.

IMPROVEMENT OF TALLAHATCHEE RIVER, MISSISSIPPI.

The United States steamer Thomas B. Florence was sent to the Tallahatchee River in September with a working force for the purpose of removing the obstructions to navigation. These consisted principally of logs and leaning timber.

The banks were cleared to within about 20 miles of Sharkey's, which is regarded as the head of navigation.

The work seems to have given general satisfaction to the steamboat interests, and greatly facilitates the shipment of the products of the country. The work executed is as follows:

Number of trees cut down	19,444
Number of trees girdled	5,937

The report of Capt. John J. Barry, in charge of the work, is appended.

At the time the first examination of the Tallahatchee and Cold Water rivers was made the water was quite high. To obtain more information upon the river, and also upon the necessity of continuing the improvement, I sent Mr. Joseph Burney, assistant engineer, to re-examine the River. He started in at the headwaters of the Coldwater, and continued down through the Tallahatchee. His report will be found appended to that on the Coldwater.

During the coming season it is proposed to operate as before in removing the obstructions from the river. A force will work between Batesville (on the Upper Tallahatchee) and the mouth of the Coldwater, and another from this latter point to the junction with the Yazoo.

The estimated cost of the improvement of this river was $40,000.

The former appropriations are as follows:

By act approved March 3, 1879	$6,000 00
By act approved June 14, 1880	9,000 00

For collection district and port of entry, see report for improving Yazoo River, Mississippi.

COMMERCIAL STATISTICS.

The Tallahatchee is a stream of considerable importance, the principal production along its shores being cotton, of which great quantities are produced, and which has no other outlet to a market but through the Tallahatchee to the Yazoo, and from there to Vicksburg, where it is reshipped to New Orleans and other ports.

There are quite a number of prosperous little towns scattered along its banks, all being of more or less importance as shipping points, and having some of the finest cotton-producing lands in the State of Mississippi to support them.

There is a line of steamers that do a yearly business in the Tallahatchee, going as far as Sharkey's Landing, and the probabilities are that they would make occasional trips into the Coldwater if the river above Sharkey's was in good navigable condition. As it is, the planters along the banks of the Coldwater and Upper Tallahatchee have to haul their cotton a long distance before they can ship to any outside market, and have to do the same when receiving any return freight.

The country as a general thing, from the mouth of the Tallahatchee to Sharkey's Landing, is well settled by white and black, and there is also considerable waste land that would probably become settled if there were good river transportation for the produce of the country.

Money statement.

July 1, 1879, amount available	$6,000 00	
Amount appropriated by act approved June 14, 1880	9,000 00	
		$15,000 00
July 1, 1880, amount expended during fiscal year		4,177 00
July 1, 1880, amount available		10,823 00

Amount (estimated) required for completion of existing project $25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882. 10,000 00

REPORT OF CAPT. JOHN J. BARRY.

UNITED STATES STEAMER T. B. FLORENCE,
Tallahatchee River.

MAJOR: The steamer T. B. Florence arrived in Tallahatchee River on the morning of September 18, with everything pertaining to the boat in good order, and work was commenced immediately.

We found the river in rather an unnavigable condition, on account of obstructions in the way, consisting of leaning timber, the timber leaning from both banks. The river being only of moderate width at an ordinary stage of water, that with its short points makes the leaning timber more of an obstruction to navigation than in other rivers where there is more space from bank to bank. The stage of water was somewhat high but declining fast.

The amount of work done from September 18 to 30 was 1,955 cuts made and 275 trees girdled. A great many cuts are made of which there is no record kept, the timber being too small to allow of their being classed as cuts, but nevertheless they require both time and trouble and are almost as necessary to open successful navigation as others that are larger. For instance, if the limbs are not cut from a large tree after it is cut down, it would meet with other obstructions in the river, and in any small river where there is much cutting to be done it would eventually form itself into a raft, whereas when the limbs are cut it will float out more successfully.

The work of cutting timber progressed from day to day until the 20th of October, when we had reached a point 30 miles up the river, making the portion we had gone over safe for steamers to navigate, as far as the danger from leaning timber was concerned.

At this point the stage of water was extremely low, while the banks on both sides were, if anything, in a worse condition than the portion of the river we had passed over, there being almost a continual growth of leaning timber that required cutting, as in some places it was nearly impossible for steamboats to navigate with safety.

From October 20 to November 1 we cut a distance of 10 miles, making a total of 40 miles which had been cut from the mouth, or, in other words, from the Yazoo River. From this point up the banks were in much better condition, the leaning timber not interrupting navigation enough to do it any serious injury. The river was very low and still declining.

On November 10 we moved up to within 40 miles of Sharkey's Landing, that being considered the head of navigation on the Tallahatchee River, and about 50 miles from the mouth of Coldwater.

Below Sharkey's for some distance we cut only the worst portions of the river as the season was growing late and our object being to accomplish as much general good as possible in the time allotted.

After working in this part of the river for about ten days, we started for the Coldwater, a distance of 70 miles from where we were then working, at which place we arrived November 22.

Our trip through the Tallahatchee from Sharkey's Landing to Coldwater was through a stretch of very bad river.

For 30 miles above Sharkey's Landing it is almost impossible for steamboats to navigate, the leaning timber nearly meeting each other as it leans over from both banks, and at any stage of water it is next to impossible for boats of any dimensions to get through into the Coldwater. The other portion of the Tallahatchee above, and this side of the mouth of the Coldwater, is in much better condition, being wider and more free from obstructions of any description.

There is also a portion of the river below Sharkey's Landing, about 16 miles, which was left uncut for want of time, and which would be of considerable benefit to the river interest were it cut. It comprises in the way of obstructions principally leaning timber.

On the 24th of December we started on our way out of both Coldwater and the Tallahatchee, the water being at such a stage that it would have been useless to continue cutting timber, as the banks were overflowed to such an extent that the trees would have had to be cut so high the stumps left would become serious obstructions during low-water.

On our way down the river nothing of special interest occurred, and we arrived at Vicksburg December 26 in good condition. We laid over there one day to take on coal and attend to other matters pertaining to the Florence, and left for Red River Landing on the following day, where the steamer was turned over to Captain Lydon as directed.

The total amount of work done by the steamer Florence is as follows:

	Cuts.	Trees girdled.
September	1,955	275
October	7,819	3,564
November	7,062	2,078
December	3,608	20
Total	19,444	5,937

Very respectfully, your obedient servant,

JOHN J. BARRY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 15.

IMPROVEMENT OF COLDWATER RIVER, MISSISSIPPI.

The steamer Florence left the Tallahatchee in November and proceeded into the Coldwater for a short season's work, cutting down leaning timber along the banks. The amount of work performed amounts to 2,125 trees cut and 652 trees girdled.

During the coming season it is proposed to operate in the lower stretch of river to the same intent as above. This section of the river I deem it only necessary to improve.

The nature of the Coldwater is such that unless a great deal of work be done upon the river, which of course will cost considerable money, boats cannot navigate it with safety. The commerce of the country I do not think warrants, at the present time, any considerable expenditure.

The former appropriations are as follows:

By act approved March 3, 1879	$7,000
By act approved June 14, 1880	4,000

COMMERCIAL STATISTICS.

The amount of cotton raised in the section of country above Belen is about 1,200 bales per annum, which is now sent by wagons to Jonestown, a distance of 16 miles, and costing $3.50 per bale to send it to New Orleans. If there were good navigation in this part of the Coldwater, cotton could be sent to New Orleans for $2.50 per bale. There is plenty of good land in this section, though the country is but thinly settled, as all means of transportation is so difficult.

For port of entry and collection district, see report for improving Yazoo River, Mississippi.

Money statement.

July 1, 1879, amount available	$7,000 00	
Amount appropriated by act approved June 14, 1880	4,000 00	
		$11,000 00
July 1, 1880, amount expended during fiscal year		2,218 05
July 1, 1880, amount available		8,781 95

REPORT OF CAPT. JOHN J. BARRY.

UNITED STATES STEAMER T. B. FLORENCE,
Coldwater River.

MAJOR: The steamer Florence entered the Coldwater November 22, and for the first 15 miles from its mouth we found the river narrow and crooked, with a great many short bends. There were but few snags in this stretch of the river and not enough

to do any serious damage when the channel is traveled, the leaning timber being cut out by us as we went up. The next 10 miles of the river we found in rather a good condition, being wide and straight with scarcely any obstructions, and none that might be considered very dangerous to navigation. This brings us to Belen, the head of navigation on the Coldwater. No boats go higher up than this point, there being no settlements for the next 40 or 50 miles, and consequently no business. The Florence, however, proceeded about 15 miles above Belen. After leaving Belen, for the first 5 miles, we had no trouble, as the river was about 8 feet above low-water mark. After we had gone the first 5 miles the water began to decline, and we found a great many snags and stumps of trees that had been cut, perhaps by the gunboat fleet that came through the Yazoo Pass. As they came through in very high water they cut these trees high up, as there was plenty of water in this river when the Yazoo Pass was open, and now these stumps in some places are 3 or 4 feet out of water, and a great many of them in the center of the channel. It takes fully a 10-foot rise to let a boat go over them with anything like safety; the river was more or less this way for about 2 miles, and then we found a very good stretch of river for about 3 miles, with very few snags. The next 5 miles was not so good, the banks being lined on both sides with a great deal of leaning timber, which we proceeded to cut down.

Although we cut down all the leaning timber in the 15 miles above Belen, still it is not safe for boats to go much higher up than that place, even with 8 feet of water, as some of the stumps spoken of are just under the water, and as there is but little or no current in this river, there is no break on the top of the water to indicate their location and you cannot find them unless the water is low enough for them to be seen, or to do as we did, take a skiff and hunt for them.

Sometimes we would find four or five of these stumps in a line across the river with scarcely room enough to go between, for when the boat is swung so as to go between them there is danger of knocking a hole in the stern as she swings towards the bank. The low-water mark is about 20 or 24 inches, but these stumps being in the way, together with the leaning trees that naturally drop into the river, many of which are not even covered, navigation above Belen is so obstructed that even a 5 or 6 foot rise is of no use to steamboats in the present condition of the river. The channel is about 25 feet wide during the low-water season, which continues throughout all the summer months, subject, however, to a rise after a heavy rain of two days, when the river will rise 5 or 6 inches or perhaps a foot, but goes down again as quickly as it rose. At the time the Florence entered the Coldwater we had about 8 feet of water, but in five days it had fallen almost 4 feet, so that we had to lay up at the bank and send the men up the river in skiffs and wait for another rise, which occurred in a few days. Since the Yazoo Pass was closed no boats have attempted to go higher up than Belen, and only one or two small boats have gone that far in the last two years, they coming late in the season.

The amount of work done by the steamer Florence during a portion of the months of November and December is as follows:

Total number of cuts made, 2,125; total number of trees girdled, 652.

Very respectfully,

JOHN J. BARRY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

EXAMINATION OF COLDWATER AND TALLAHATCHEE RIVERS.—REPORT OF MR. JOSEPH BURNEY.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 19, 1880.

MAJOR: In accordance with your instructions, I have made an examination of Coldwater and Tallahatchee rivers, running through the counties of De Soto, Tunica, Coahoma, Tallahatchee, and Le Flore, in the State of Mississippi, and respectfully submit the following report:

I commenced the examination of Coldwater about 30 miles below Memphis, Tenn., proceeding down the river in a skiff pulled by two skiffmen. For the first 60 miles, to Prattsville, the river was at a low stage, narrow and crooked, and we met a great number of jams extending across the river, over which we had to drag our skiff. Near Prattsville we encountered a solid jam about one-fourth of a mile long, and on walking down the bank of the river for about 5 miles, I found several similar jams, resembling those on Red River above Shreveport before their removal. On making inquiries I was informed the jams extended for a considerable distance down the river, and that they had been in for a number of years. In order to get below them I had the skiff hauled by wagon to Hudson's Ferry, a distance of 17 miles by land and about 50 miles by water. From Hudson's Ferry upwards I found the river entirely unsuitable for navi-

gable purposes. Below the ferry the river widened out into a good navigable river for 25 miles, when it became again narrow and crooked for about 5 miles. We found three slight jams, below which we readily passed. Below this point the river was about half-bank full, and to the mouth we found a good navigable stage of water.

In passing down the river I only saw one small town on the banks, located about 25 miles above the mouth of the river, named Belen, it contains 4 stores and about 50 inhabitants. The navigable portion of Coldwater runs through a thinly settled country, a large portion of the land being covered with heavy cane and timber. Very little business is done on the river, although the lower part is navigable for about six months in the year. I was informed there had been no steamboats on it for many years, with the exception of the United States steamer Florence, which went up the river 40 miles last year improving the channel. The only water craft used at present on the river consists of ferry boats to cross the stream at various points, one flat-boat to carry staves, and at Belen they had one large skiff having a water-wheel worked by hand, capable of carring 25 bales of cotton, and two large dugouts fastened together and capable of carrying five bales of cotton. What little business is done on the west bank goes to the Mississippi River and on the east bank to the Mississippi and Tennessee Railroad.

Tallahatchee River is formed by a junction of Coldwater and Little Tallahatchee rivers, in Coahoma County, and runs to its mouth, a distance of about 210 miles, where it empties into the Yazoo River.

From the mouth of Coldwater to Sharkey's Landing on the Tallahatchee, a distance of 100 miles, the river runs through a wild and thinly-settled country.

From Sharkey's Landing to the mouth, a distance of 110 miles, the river runs through a well settled and very rich country, being one of the finest cotton districts in the Southern States. During the cotton season two steamboats run from Vicksburg to Sharkey's Landing every week, but during the summer season this is reduced to one steamboat per week.

For six months in the year the whole of the Big Tallahatchee River, and for 100 miles up the Coldwater, is navigable without any further improvement.

From inquiries made from planters living near the river, and from steamboat men running on the Tallahatchee and Yazoo rivers, I am informed it would be no benefit to improve the upper part of Tallahatchee above Sharkey's, nor any portion of Coldwater River, for the business is so small and so readily accessible to the Mississippi River on the west, and to the Mississippi and Tennessee Railroad on the east, that the business offered on the river would not be sufficient to pay a single steamboat to run, consequently, if no steamboat would run on that part of the two rivers any improvement made would be useless.

During the last fall, the United States steamer Florence did a large amount of work on Coldwater and Tallahatchee rivers, in cutting and removing overhanging trees and deadening timber on the banks; the work done below Sharkey's has given satisfaction to the steamboat men, but the work done above that point they state is of no benefit to them; they request me to respectfully recommend to you that any future work done on the Tallahatchee River should be done below Sharkey's Landing, and that it consist of the removal of snags from the channel by a light-draught snagboat, in the low-water season.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 16.

IMPROVEMENT OF FOURCHE LA FÈVE RIVER, ARKANSAS.

Instead of building a flat-boat and placing upon it the necessary machinery for pulling snags and removing rocks, as originally contemplated in the project for the improvement of this stream, a complete outfit, consisting of 3 barges, was hired; one with steam power; one for the working party engaged in clearing timber from the banks; and a third as quarters for the men.

The party was organized and left Dardanelle, Ark., August 28, and arrived at the mouth of the Fourche la Fève the following day, and immediately commenced work. Edward H. Flood had charge of the operations in the river.

The following is a statement of the amount of work done:

Total number of trees cut	6,687
Total number of snags removed	890

In addition to the above, about 25,000 trees on both banks of the river were deadened, and a number of rocks were removed from the shoals at Kirk's, Turner Rock, Red Ferry, Indian Grave, Piney Point, and Mrs. May's.

Extracts from Captain Flood's report showing the condition of the river and amount of work done are appended.

The bar at the mouth has a depth of from 2½ to 3 feet of water when the river is at its lowest stage, and in the first 5 miles there is an average depth of 12 feet in the channel, and a width of from 125 to 150 feet. When at its highest stage the river is over 300 feet in the clear. The banks are very bluff.

In noticing this river, I find that when the Arkansas River is above the level of the Fourche there is back water for about 3 miles, and all the drift remains perfectly still, and it is only when there is a heavy rise that there is any sort of a current, and this is the reason there are so many snags in it.

After taking out all the snags in the first 5 miles, I had to remove a shoal called King's Shoal about 5½ miles above the mouth. It was composed of small loose rocks, which were very easy to remove. Nearly all the trees cut were large ash and sycamore, many of them were leaning, and were a great deal of trouble, having to let them fall on the boats and then carry them ashore.

The snags were principally large sycamores, which were held by their roots and had to be cut in small pieces and carried ashore, as they were too heavy to float.

Turner Rock Shoal, about one-half a mile below Red Ferry, and about 300 yards in length, composed of solid rock, was removed.

On October 16 I commenced breaking out large pieces of slate-rock from Red Ferry Shoal, and digging away at least 10 feet of the embankment which had formed and caused a bend in the river. The reason I operated in this way was to straighten the river and give the water a better sweep, which would cause the bank to cave in very rapidly when the river rose. This shoal so far was the worst we had met with, having at least 18 inches of a fall over it, and to enable me to get the boats over this fall I had to build a temporary brush-dam to give sufficient water-level to do it.

At the mouth of Mill Creek I found the river filled with sunken timber, and it was impossible to pass the boats over before removing it. I had it hauled out on both banks, leaving about 2½ feet of water at that place. I found it was the same at a place called Duck Creek. There was more sunken timber in this portion of the river than any we had worked in thus far; it looked as if it were matted at the bottom of the river, but it was not very troublesome to pull out.

On the 5th November I arrived at Indian Grave Shoal, and found 4 inches of water on it; the shoal is about 300 feet long, composed of slate rock. A passage-way sufficient for the boats to navigate was cut through.

The next place was Piney Point Shoal, about 400 feet long and about 40 feet in width; there was only 3 inches of water when I commenced work on it, which I deepened to about 18.

The May Shoal was the next one which I could not pass without removing a large raft of 100 sticks of timber which had lodged right across the shoal; after removing the raft had no difficulty in getting the boats through.

I did not find as many snags between the last shoals I passed as I did in the lower river, but I found a great deal more leaning timber, which was cut down and hauled out.

On December 30 I reached Perryville and made arrangements to start down the river.

On December 31 I reached Red Ferry Shoal and discharged all hands.

On the way down the river I was accompanied by 12 large rafts.

Number of trees cut down during the months of August and September	1,177
Number of snags pulled	200
Number of trees cut down during the month of October	665
Number of snags pulled	283
Number of trees cut down during the month of November	1,605
Number of snags pulled	203
Number of trees cut down during the month of December	3,240
Number of snags pulled	204

RECAPITULATION.

Total number of trees cut	6,687
Total number of snags pulled	890

In addition to the above there were 25,000 trees deadened on both banks of the river. Have also cleaned off and left a depth of at least 18 inches (at low-water mark) on Kirk's, Turner's Rock, Red Ferry, Indian Grave, Piney Point, and Mrs. May shoals.

I could not do any work on Alford's Shoal on account of water, there being at least 3 feet of water over it.

There was also removed a large number of rafts from the different shoals, so as to give me a chance to operate. There was also taken out a large quantity of sunken timber.

In going down the river I found a good many trees with limbs overhanging the stream, which were not in the way during low-water; these I removed, and also any drift which I found had lodged.

The last rise, which I mentioned in report No. 17, cleaned out the river, and carried with it all the loose timber lying on the banks, leaving a depth of at least 12 feet on the outer bar at the mouth.

Taking a general view of the river since the work has been done, I think it is one of the prettiest in Arkansas.

The amount asked for for June, 1882, will be expended in improving the shoal places in the river and removing all obstructions from the bed and banks of the stream.

The appropriations made are as follows:

By act approved March 3, 1879	$10,000
By act approved June 14, 1880	4,000

For port of entry and collection district, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	4,000 00	
		$14,000 00
July 1, 1880, amount expended during fiscal year		9,200 26
July 1, 1880, amount available		4,799 74
Amount that can be profitably expended in fiscal year ending June 30, 1882.		5,000 00

O 17.

IMPROVEMENT OF SALINE RIVER, ARKANSAS.

No work has heretofore been done on this stream. During the coming season it is proposed to remove the obstructions from the bed and banks of the stream. For this purpose a flatboat, provided with the necessary machinery and outfit, will be employed.

With the appropriation asked for the fiscal year ending June 30, 1882, it is proposed to continue the improvement in the same way as above.

The original estimate for the improvement of this river was $30,151.
Amount appropriated by act approved June 14, 1880, $7,500.

COMMERCIAL STATISTICS.

The amount of commerce carried on during a period of six months of the year embraced about 20,000 bales of cotton, besides a large quantity of hides, tobacco, staves, timber, &c. To this should be added a corresponding amount of return freight.

It is said by many cotton growers and storekeepers along the stream that if the navigation of the Saline River were improved the value of freight transportation would amount to over $2,000,000 per annum.

For port of entry and collection district see report for improving Ouachita River, Arkansas and Louisiana.

Money statement.

Amount appropriated by act approved June 14, 1880	$7,500 00
July 1, 1880, amount available	7,500 00
Amount (estimated) required for completion of existing project	22,651 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	12,000 00

O 18.

IMPROVEMENT OF BLACK RIVER, ARKANSAS.

No work has heretofore been done upon this stream. With the appropriation of $15,000 it is proposed to employ a light-draught boat, properly equipped, and with a full working force engaged in removing obstructions from the bed and banks of the river. Parties will also be engaged, as far as the appropriation will admit, in deepening some of the shoal places and in building dams at the head of Big Island and other points for the purpose of concentrating the water when at a low stage into a single channel

With the appropriation of $15,000 asked for it is proposed to continue the above work. The total estimated cost of this improvement, including light-draught boat, was $80,800.

COMMERCIAL STATISTICS.

From the Upper Black great quantities of staves are taken for export to foreign ports, and from the Lower Black it is estimated that from 10,000 to 12,000 bales of cotton are shipped to the Memphis and other markets, and other shipments (amount not known) go over the Saint Louis and Iron Mountain Railroad to Saint Louis. If the river were improved, adding additional facilities for handling the crops, there is no doubt but what the cotton shipments would be increased.

For collection district and port of entry, see report for improving Mississippi River and harbor at Memphis, Tenn.

Money statement.

Amount appropriated by act approved June 14, 1880	$15,000 00
July 1, 1880, amount available	15,000 00
Amount (estimated) required for completion of existing project	65,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	15,000 00

EXAMINATION OF BLACK RIVER, MISSOURI AND ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1879.

GENERAL: I have the honor to present the following report upon the examination of Black River, Missouri and Arkansas, provided for by act of Congress approved March 3, 1879, and assigned to me by letter dated April 25, 1879.

This examination was made with a view of determining the character of the stream, the nature of the obstructions, and cost of removal of same, and the amount of commerce to be benefited. The operations in the field were conducted by Mr. I. D. McKown, assistant engineer, and extended from Poplar Bluff, Mo., to Jacksonport, Ark.

Examinations of this stream were made under the direction of Lieutenant-Colonel Raynolds in 1871, by Mr. John S. Tennyson, from Pocahontas to the mouth, and in 1872, by Mr. A. H. Blaisdell, from Poplar Bluff to Pocahontas. From these different reports, full and detailed information regarding the obstructions has been obtained, which enables us to present estimates for the improvement of the river.

Black River is a tributary of White River, heading in the southeastern part of Missouri, and, flowing in a general southwesterly direction, empties into the White about half a mile above Jacksonport, Ark. It has a number of tributaries, the principal ones being Cane Creek, Current River, and Fourche de Mas, while at different points it divides itself into two branches, forming separate channels, such as Dan's River, Little River, and Catharine Slough. In addition, there are numerous sloughs leading off from the main river into the bottom lands on either side; the drainage area of the whole being estimated at about 8,000 square miles.

It is considered necessary to improve only that portion of the river between Poplar Bluff and the mouth; the estimated distance being about 300 miles.

The banks of the river are of a firm material, but little liable to cave, and therefore any improvement that may be undertaken would be comparatively permanent.

During extreme high-water the banks and bottom lands are in many places liable to overflow. The extremes of high-water vary from 18.5 feet at Poplar Bluff to 26.25 feet at Pocahontas. The river bed is generally sandy; on its lower parts sand and clay sometimes mingled with muscle-shells and fine gravel. The general width between banks on the upper section of the river is about 130 feet, and on the lower, say below the mouth of Current River, the average width is about 250 feet.

The general obstructions to navigation are shoals, snags, logs, and leaning timber. About four miles above the head of Little River, the Saint Louis, Iron Mountain and Southern Railroad has constructed a bridge of a single fixed span of 160 feet across the river, the height of the lower chord of the bridge being only 11 feet above low-water; it is therefore a complete obstruction to the navigation of the river above.

For convenience the river is divided into two divisions, viz, from Poplar Bluff to Current River, a distance of about 146 miles, and from Current River to the junction with the White. In the first division there are fifty-seven shoals, covering an aggregate length of 37 miles, the depth of water over these shoals being never less than two feet except in one or two instances. In the second division there are twenty-one shoal places, the depth of water over them varying from two feet to two and one half feet. A list of these shoals taken from the reports above referred to is here inserted:

Name.	Length.	Channel in low-water. Depth.	Channel in low-water. Width.	Remarks.
	Feet.	*Feet.*	*Feet.*	
Henderson	600	2 to 4	40	Gravel and sand bottom; logs in channel.
No name	600	2 to 3	60	Sand bottom.
Do	300	3 to 4	30	Sand bottom.
Do	150	2.5	35	Gravel and sand bottom.
Do	300	2.6	35	Gravel and sand bottom.
Do	150	3	30	
Do	150	3	35	Bottom of snags imbedded in sand.
Do	175	2.5 to 3	30	
Do	250	2.5	30	
Do	300	3	40	
Do	220	3	40	Used as a ford.
Do	100	3	30	
Do	120	3	25	
Do	75	2.5	40	
Do	100	2.5	30	All these shoals occur in bends. The river itself is very narrow in this locality.
Do	150	3	30	
Do	300	2.5	40	
Do	150	2.8	30	
Do	150	2.5	30	
Do	1,000	2.5	30	
Do	400	3	30	
Do	150	3	20	
Do	600	3	40	
Do	350	3	30	At mouth of Dan's River.
Do	100	3.5	50	
Do	250	3.2	40	
Do	400	2 to 3.5	40	
Do	650	2 to 3	30	
Do	150	2 to 2.5	30	
Do	250	3	40	
Do	1,300	2 to 3	90	
Do	300	2 to 3	20	In bend Roaring "cut-off."
Do	100	2.5	30	
Do	350	3	30	
Do	300	2.8	40	
Do	200	3.3	35	Sand, with muscle-shells.
Do	300	3.3	35	
Do	200	3	40	
Do	75	3.5	30	Between these limits there is a general good depth of water.
Do	250	3	50	
Do	100	2.3 to 3	40	
Do	2,400	2.5 to 3	30	
Do	250	2.5 to 3	40	In many of these shoals the bottom is overgrown by a species of grass which renders the bottom very hard.
Do	250	1.5 to 3.5	40	
Do	300	3 to 4.5	50	
Do	100	2 to 3	50	
Do	200	1.5 to 3.5	50	
Do	300	2.5	50	
Do	600	2.5	40	
Do	100	2.2	40	
Cox's Ford	1,000	2	180	Fall .6 Rocky bottom.
Fish Trap	75	2.5	30	Fall .25
No name	900	2.5	50	
Do	150	2	30	
Rocky Ford	300	2 to 2.5	40	Rocky bottom; fall .25.
Russell's Ferry	450	3	60	Sand bottom.
No name	900	2 to 3	60	Sand and muscle-shells on bottom.
Shoals of Pocahontas	800	2.4	40	Rocky bottom.
No name	400	2.6	40	Gravel bottom.
Do	500	2.4	40	Gravel bottom.
Do	350	2.6	45	Two large loose rocks in channel.
Do	600	2	40	Gravel bottom.
Do	500	2.4	45	Do.
Do	300	2.4	35	Do.
Spring River	700	2.4	40	Do.
Devil's Race Paths	850	2.3	35	Do.
Lower Devil's Race Path	700	2.3	35	Do.
Eagle's Nest	350	1.10	33	Do.
No name	450	2.3	35	Do.
Powhatan	900	2.3	35	Do.
No name	400	2.3	35	Do.
Do	350	2.3	40	Do.
Do	500	2.6	40	Logs on the bottom.
Tim' ictory	350	2.6	33	Gravel bottom.
Berkeley's	350	2.5	40	Gravel bottom.
Little Paroquitt	500	2.6	40	Gravel and logs.
Paroquitt	450	2.6	45	Gravel and logs.
No name	350	2.6	40	Gravel bottom.

In addition to the shoals there are a great number of leaning trees which should be cut down, and numerous snags that ought to be removed.

Some improvements were attempted in former years upon the Upper Black by the State of Missouri, the money being raised by donation of swamp lands; nothing, however, was attempted beyond cutting down leaning timber and removing snags in the vicinity of Poplar Bluff.

The stream is regarded as affording very good facilities for navigation. A regular line of boats has for several years past been plying between points on the Lower White and Pocahontas on the Black. If the improvement of the river be carried on, it will add greatly to the commercial and agricultural interests of the country tributary to the river.

Regarding the improvement, as the character of the stream is such as not to admit of its navigation by boats of a large size or carrying capacity during the low-water season, it is recommended to remove the snags, logs, &c., cut down the leaning timber, improve several of the shoal places, and close up several of the small sloughs where the channel is divided, thus concentrating the water into single channels.

Above the mouth of Current River it is recommended to deepen a few of the shoal places, otherwise to confine the work to the removal of snags, &c., and the cutting down of leaning timber; also, at the head of Big Island, where the river divides itself into two channels, to put a dam across the head of Little River, and confine the water to the main channel. A few small sloughs below would require similar treatment; about 500 feet of dam, including that at Little River, would be sufficient for the upper division.

Below the mouth of Current River, in addition to leaning timber, &c., there are three shoals requiring improvement, viz: Devil's Race Path, Eagle Nest Shoals, and shoals at the mouth of river. The Devil's Race Path Shoal is of gravel bottom. The water is divided into two channels and could be improved by constructing a dam, closing up one of the chutes.

Eagle's Nest Shoal is also gravel bottom. It has the least depth over it of all the shoal places noted—only about 22 inches at extreme low water. A wing-dam to contract the waterway and deepen the channel would improve it.

The shoal at the mouth is probably the most troublesome. Sunken logs firmly imbedded in the bottom obstruct the channel, rendering the passage of steamers difficult and somewhat dangerous at low-water. If these were removed, and a low dam built, it would make a desirable improvement.

For the improvement of Black River I estimate as follows:

1 small light-draught boat	$20,000
2 seasons' work, 7 months in each season, at $2,200 per month	30,800
Cutting trees along the bank, two seasons' work	8,000
3,500 feet of dam, at $4 per foot	14,000
Engineering and contingencies	8,000
	80,000

I have estimated, as will be observed, for a small light-draught snagboat. Such an one is required not only on Black River, but on many other small streams of like character that need improving in this section of the country, and upon which the ordinary light-draught snagboats now in service cannot be used.

COMMERCIAL STATISTICS.

From the Upper Black great quantities of staves are taken for export to foreign ports, and from the Lower Black it is estimated that from

10,000 to 12,000 bales of cotton are shipped to the Memphis and other markets, and other shipments (amount not known) go over the Saint Louis and Iron Mountain Railroad to Saint Louis. If the river were improved, adding additional facilities for handling the crops, there is no doubt but what the cotton shipments would be greatly increased.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 19.

IMPROVEMENT OF BIG HATCHIE RIVER, TENNESSEE.

No work has heretofore been done by the government upon this stream. During the coming season it is proposed to procure a light-draught steamboat, and with a proper working force engage in the removal of such obstructions as will aid the safe navigation of the stream and facilitate the shipment of the produce of the adjacent country. With the amount asked for for June, 1882, it is proposed to continue the same work.

The original estimate for the improvement of the Hatchie was $30,000.
The amount appropriated by act approved June 14, 1880, is $10,000.

COMMERCIAL STATISTICS.

The Hatchie River runs through an old-settled and well-cultivated country, where a large amount of cotton, corn, cattle, and other stock is raised, and on the banks are very valuable timber lands, from which a large amount of saw-logs are obtained, and upwards of 400,000 white-oak staves are shipped annually to the New Orleans market.

Memphis is the natural market for the sale of cotton and for obtaining supplies for this district, but the railroads have so arranged their freight charges that the business has been done at other points. At Estoynella, about 100 miles from Bolivar, the produce has to be hauled from 12 to 15 miles to the railroad; but should the river be improved and open to navigation the distance to steamboat landings would be short.

The price for carrying a bale of cotton by railroad from Bolivar to Memphis, a distance of 70 miles, was $2.75, and it has lately been increased to $3.25. The charge from Bolivar to New Orleans, a distance of over 400 miles, is also $3.25. By steamboat cotton can be carried for $1.50 per bale, and it is estimated that 15,000 bales would be transported annually, which would effect a saving on freight of not less than $1 per bale, making $15,000; and estimating a saving on return freight at the same amount, an annual saving of $30,000 would be made were the river opened to safe navigation.

For collection district and port of entry, see report for improving harbor and Mississippi River at Memphis, Tenn.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	10,000 00

EXAMINATION OF BIG HATCHIE RIVER, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1879.

GENERAL: I have the honor to transmit herewith the report of Mr. Joseph Burney, assistant engineer, upon the examination of Big Hatchie

River, Tennessee, made under my direction in accordance with instructions from your office under date of June 16 last. The sum allotted for the work was from the appropriation of August 14, 1876, "for examinations and surveys of such rivers and harbors as, in the judgment of the Secretary of War, will subserve the general interests of commerce."

The question of making an examination of Hatchie River was referred to me in March, 1877; but at that time an act of the legislature of the State of Tennessee was in force, which declared that the river was not a navigable stream, whereby the railroad companies were allowed to build bridges without draws across the river. Under such a condition of affairs nothing was attempted by the United States in the way of making the contemplated examination. The act referred to was repealed at the last session of the legislature, and Hatchie River is again open to navigation, the railroad companies having altered their bridges to conform to the law.

The examination extended from Bolivar to the mouth, a distance estimated at 240 miles, and was made when the river was at its lowest stage, and consequently all obstructions to navigation were noted. These obstructions consist of snags, logs, and leaning timber, and their removal would constitute the principal improvement to be carried on, in order to render the Hatchie a navigable stream for light-draught boats throughout the entire year.

The opening of this river, which flows through the richest and most productive region of West Tennessee, will greatly promote the agricultural and commercial interests of that section, and will furnish an additional outlet for the transportation of the productions to market at a greatly reduced cost.

In addition to the shipments of staves, which are transported for home and foreign markets, it is estimated that 15,000 bales of cotton will be shipped from the river, finding a market in Memphis.

The estimated cost of the improvement of the river is $30,000.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JOSEPH BURNEY, ASSISTANT ENGINEER.

MEMPHIS, TENN., *December* 11, 1879.

MAJOR: In accordance with your instructions to make an examination of the Big Hatchie River from Bolivar to the mouth, with an estimate for improving the navigation of the same, I respectfully submit the following report:

Upon receiving your instructions, I immediately proceeded to Bolivar, Tenn., purchased a skiff, engaged two boatmen, and proceeded slowly down the river, making inquiries and observations at every possible point along the way.

The Hatchie River, from Bolivar to the mouth, is in the State of Tennessee, and runs through the counties of Lauderdale, Tipton, Haywood, and Hardeman, a distance estimated at 240 miles, entering the Mississippi River 60 miles above Memphis. I consider the river equal in size to the Yazoo River in Mississippi and the Ouachita River in Louisiana and Arkansas, and capable of being navigated by boats of a capacity adapted to those streams.

Before the year 1866 the Hatchie River was a lawful navigable stream, and from six to seven steamboats were fully employed during the cotton season, some of which were side-wheel boats, having a carrying capacity of from 1,500 to 1,600 bales of cotton. Navigation was not even suspended during the lowest stage of water, for there is always sufficient depth for boats drawing 2 feet.

About the year 1858 the State of Tennessee appropriated $32,000 for the improve-

ment of the river, the expenditure of which placed the stream in a navigable condition, and a very large amount of business was done upon it. In the year 1866 the State legislature of Tennessee declared the Hatchie to be an unnavigable stream, and gave permission to the Mississippi Central, the Memphis and Louisville, and Memphis and Paducah Railroad Companies to construct bridges across it, which created an effectual blockade, and although many attempts have since been made to navigate the river, which has led to much litigation, and the United States remaining silent on the question, navigation has been entirely suspended.

During the present year the legislature repealed their former act and declared the Hatchie once more to be a navigable stream, and ordered the Memphis and Louisville Railroad Company to alter their bridge and put in a draw span.

The principal obstructions to navigation are:

1st. The iron bridge across the river near Brownsville, Tenn., belonging to the Memphis and Louisville Railroad Company. The bridge is now being altered so as to make it a drawbridge, and will soon be completed, which will entirely do away with this obstruction.

2d. The Memphis and Paducah Railroad bridge near Covington, Tenn. This bridge is constructed of wood and can easily be removed.

3d. The leaning trees.

4th. The snags, of which there are a great number, making it very difficult and dangerous for the steamboats to navigate the river until they are removed.

After a careful examination, and after consulting experienced river men, I estimate that it will take three years to thoroughly improve the river, at a cost of $30,000.

I would respectfully recommend that the work be done by chartering a light-draught steamboat with a working crew, to remove the obstructions from the river and cut down the leaning trees. The expense of such a boat and crew would be from $100 to $120 per day; this would allow, say:

Four months' work in 1880	$15,000
Three months' work in 1881	10,000
Two months' work in 1882	5,000
Total estimate	30,000

The Hatchie River runs through an old-settled and well-cultivated country, where a large amount of cotton, corn, cattle, and other stock is raised, and on the banks are very valuable timber lands, from which a large amount of saw-logs are obtained, and upwards of 400,000 white-oak staves are shipped annually to the New Orleans market.

Memphis is the natural market for the sale of cotton and for obtaining supplies for this district, but the railroads have so arranged their freight charges that the business has been done at other points. The price for carrying a bale of cotton from Bolivar to Memphis—a distance of 70 miles—was $2.75, and it has lately been increased to $3.25. The charges from Bolivar to New Orleans—a distance of over 400 miles—is also $3.25. At Estoyuella, about 120 miles from Bolivar, the produce has to be hauled from 12 to 15 miles to the railroad, but should the river be improved and open to navigation the distance to steamboat landings would be short. Cotton can be carried on steamboats for $1.50 per bale, and it is estimated that 15,000 bales would be transported annually, which would effect a saving in freight of not less than $1 per bale, making $15,000; and estimating a saving on return freight at the same amount, an annual saving of $30,000 would be made by the river being open to navigation.

Since the State legislature has declared the river to be a navigable stream, thus adding 240 miles to the navigable rivers of the United States, a company has been formed at Memphis, with a capital of $25,000, to run two steamboats from Memphis to Bolivar; but until the channel is improved navigation will be very dangerous, and consequently freight charges must be high.

I believe that $30,000 would thoroughly improve the river and be of great benefit to the inhabitants of West Tennessee.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 20.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

No work has heretofore been done at this locality. With the appropriation of $40,000 made by act of Congress approved June 14 it is pro-

posed to commence the revetment and protection of the Louisiana shore along Marengo Bend, in order to stop the caving, and so prevent the Mississippi River from cutting into Lake Concordia. Work will commence as soon as the stage of water will allow.

With the appropriation asked for the fiscal year ending June 30, 1882, it is proposed to continue the work at two points, Giles Bend and Marengo Bend. The total estimated cost of this work was $939,600.

The amount of cotton shipped from this port during the month of June was 315 bales, making a total of 26,913 bales of cotton shipped between September 1, 1879, and July 1, 1880, besides a corresponding amount of return freight. The port of entry is New Orleans.

Money statement.

Amount appropriated by act approved June 14, 1880	$40,000 00
July 1, 1880, amount available	40,000 00
Amount (estimated) required for completion of existing project	899,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	150,000 00

O 21.

IMPROVEMENT OF THE MISSISSIPPI RIVER AND HARBOR AT VICKSBURG, MISSISSIPPI.

Operations upon the work for the protection of the Delta Point were resumed in June, 1879, and continued until about the middle of August, when there was an entire suspension of the work ordered, on account of the fears of certain people that yellow fever would break out among the force of laborers employed, and spread through the surrounding country. Work was resumed after a month's delay, and continued until January, when the water in the Mississippi became so high that it was absolutely necessary to suspend.

Over 4,000 feet of bank has been revetted, and thus far has successfully prevented the further caving of the bank where applied. There still remains to be protected about 1,200 feet between the upper and lower divisions of the work, and about 2,300 feet below.

The appropriation made by act of June 14 is so small, comparatively, that it will not go very far towards the completion of the work. With it I propose to continue the revetment, and repair and maintain the stability of that already done.

The original recommendations of the Board of Engineers were that the work should be carried out in the following order: 1st, protection of the Delta Point; 2d, construction of the bar dike; 3d, dredging out the inner harbor. To that intent, operations have been confined to the first purpose. The object of the bar dike was to cut off the eddy current, and prevent the filling up of the inner harbor. The position of this bar dike was on the crest of the bar which was being formed from the end of De Soto Island towards Ryan's Saw-mill. The deposit from the river, however, has been so great that the crest of this bar is now 20 feet above low-water, and fully carries out the object for which the bar dike was originally designed. Soundings made within the last few days show that although we have had a long-continued stage of high-water, there has been no appreciable fill in the inner harbor directly in front of the elevator and steamboat landing during the past year.

Under this favorable condition of affairs, it is proposed to carry out the third recommendation as above, and dredge a channel 250 feet wide

from Ryan's Mill to the front of the elevator, at which point it will be enlarged into a basin 600 feet wide and about 1,800 feet long; the total length of the cut from Ryan's Mill to the elevator being 4,800 feet.

The appropriation of $250,000 asked for is to be applied as follows: $100,000 to the revetment of the Delta Point, and $150,000 to dredging and preparing for the basin in the inner harbor.

For full details of the operations, I beg leave to refer to the report of Mr. T. G. Dabney, assistant engineer, herewith.

The former appropriations are as follows:

By act approved June 18, 1878	$84,000
By act approved March 3, 1879	50,000
By act approved June 14, 1880	20,000

COMMERCIAL STATISTICS.

During the past year, Vicksburg handled about 56,000 bales of cotton; and in addition to this there were brought to Delta, by the Vicksburg, Shreveport and Pacific Railroad, about 43,000 bales.

It is estimated that the value of the commerce of Vicksburg is between $7,000,000 and $8,000,000 per year, outside of the cotton receipts.

All the steamboats passing to and from New Orleans to points further north land at this place, and are more or less affected by the improvement of the harbor.

For port of entry and amount of revenue collected, see report on the mprovement of mouth of Red River, Louisiana.

Money statement.

July 1, 1879, amount available	$95,758 25	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$115,758 25
July 1, 1880, amount expended during fiscal year		94,971 07
July 1, 1880, amount available		20,787 18
Amount (estimated) required for completion of existing project for Delta Point		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882, for Delta Point and dredging		250,000 00

REPORT OF MR. THOMAS G. DABNEY, ASSISTANT ENGINEER.

VICKSBURG, MISS., *July* 1, 1880.

MAJOR: I have the honor to submit the following report of the work intrusted to my charge for the fiscal year just ended. I will first briefly recall the character and object of the work which I have been prosecuting here.

You will remember that in 1878 the Board of Engineers, of which General Simpson was president and Major Suter and yourself members, recommended that appropriation be made to execute certain work for the preservation of this harbor. The first step was the revetment of the Delta peninsula to prevent further caving and stop the rapid recession of the river from the vicinity of Vicksburg. The second was to construct a dike from the south end of De Soto Island across the harbor along the crest of the bar in process of formation to a point about 800 feet from the Vicksburg shore; thence nearly parallel to the bank, converging slightly southward to deep water.

The basin thus inclosed in front of the town was then to be dredged to a sufficient depth to accommodate the commerce of the place, a channel of approach being maintained to the river.

In 1878 Congress made an appropriation for this work, the amount appropriated being the estimated cost of the first step only of the system recommended for the restoration of this harbor; that is, the revetment of the caving bank along the Delta peninsula. The estimate of cost for this work was made witnout previous experience in such operations with the conditions here prevailing, very deep water and rapid current, proved too low by nearly one-half, though the cost was much increased by

exceptional untoward circumstances, as the prevalence of the yellow-fever epidemic of 1878 and the suspension of the work in 1879 from apprehensions of a similar visitation.

Owing to the experimental character of this application, a revetment of willow mattresses, and the necessity for a gradual development of the process, but little material progress was made after the subsidence of the fever in 1878, the season being exceedingly unfavorable, a strong motive existing, however, to utilize the time as far as possible and arrest the rapid caving of the bank. Valuable experience was gained, but at a considerable cost, which proved useful the following season. Last summer (1879) work was resumed as early as the stage of water in the river would permit, on the 27th of June; the operations were pushed vigorously until August 12, when there was an entire suspension of the work. This very unfortunate stoppage arose partly from the genuine fears of certain people lest yellow fever should invade my force of laborers and thence communicate itself to the adjacent country, but largely to petty bickerings and jealousies between small local boards of health; and although such an observation is perhaps out of place here, I cannot refrain from expressing the hope that the national government will assume entire control over all matters of quarantine, and regulate the subject with some kind of system and common sense, as local quarantine became an intolerable evil last year.

The danger which it was alleged was apprehended from the presence of my workmen near Delta appeared to me to be so remote and the remedy so easy, if it should arise, to wit, the dispersion of my force, that I resisted the effort to procure a stoppage of the work as far as possible, having a lively sense of the importance of utilizing so favorable a season, but an order from the Secretary of War, through yourself, required me to suspend the work as above recited on August 12. It is rather a curious fact that the inhabitants of both Vicksburg and Delta, being immediately contiguous to the work and preponderating largely in numbers, were opposed to its suspension; but the trouble came chiefly from people living along the line of railroad, in the parishes further west, from 35 to 75 miles back, their fears being magnified in proportion to their remoteness from danger.

My force of some 250 men, well organized and operating very successfully, was of course entirely dissipated. A month later the work was resumed by your order, but much more time was lost before the working force could be brought up to the same standard of strength and efficiency. This interruption was most unfortunate in all respects, greatly marring the opportunity afforded by an exceptionally long and favorable low-water season for the accomplishment of this work. On January 9 the last mattress was sunk, the river having then attained such a height as to render the operation very difficult; and, doubtful of results, the work was discontinued for the season. One hundred and twelve mattresses were constructed during the season and disposed of, nearly all successfully; 4 of them were entirely lost in the effort to sink them, and there were fragments which broke away from some others that were of extra length, but the great majority were properly sunk, my system of operating having attained a considerable degree of perfection during the progress of the work.

The revetment was carried along from the upper end of the work to a point about 2,700 feet below, which extent of bank was thoroughly well protected. At this juncture it became obvious that there was not sufficient time left to complete the work to the extremity of the peninsula. It was therefore deemed advisable to skip a portion of the bank which was retired from the current to a considerable degree, and utilize the remainder of the season in covering as much as possible of the greatly exposed locality further down. This was accordingly done, and between 1,600 and 1,700 feet of bank below the Delta wharf-boat was well covered.

The operation of sinking mattresses at this part of the work was at first very difficult, owing to the presence of deep water inshore, from 70 to 80 feet, and a remarkably strong current impinging against the bank. There were in consequence some disasters in the earlier stages of the operation, but a system was gradually perfected by which the mattresses were sunk with certainty and promptness, as many as four having been sunk in a day, with one set of men and appliances.

The mattresses were from 125 to 175 feet in length, 50 feet wide, and about 2 feet thick. On the upper extremity of the work, the slope of the bank being longer, the mattresses used were generally 175 feet long, while at the lower extremity they were 140 feet long. Some were made only 18 inches thick, but it was found much more difficult to sink them successfully in deep water and strong current.

When this extent of work had been accomplished, the river had reached so high a stage that operations were both hazardous and expensive, and the bars being to a large extent covered with water, it became impossible to procure a sufficient supply of willows. A few more mattresses were sunk in continuation of the upper part of the lower detached work, with the hope of protecting that part in some measure, they being placed parallel to the bank and covering the slope for some 50 feet below low-water line. The protection afforded by them is not very decided, though they doubtless retarded the caving.

The experiment was then made of sinking "screens" in the position of spur dikes,

a small force of workmen being retained for that purpose. This idea was obtained from Major Charles R. Suter, United States Engineer, he having used them with very good effect in the Missouri River, but under conditions quite different from those prevailing here, as he had much less depth of water and velocity of current to operate in. The experiment here was made at such a high stage of water, and consequent rapid current, and I was so much harassed with drift-wood during the operations, that no determinate result was obtained, which was a source of much regret, as I was anxious to test the principle as applicable here.

During the prevalence of high-water this season, I have watched with great interest and anxiety the effect upon the mattress revetment, and, now that the ordeal is passed, I felicitate myself upon the good condition of the work and the faithfulness with which it has resisted the attacks of the river.

The upper division of the work is absolutely intact. The lower part, being vulnerable at both its extremeties, suffered somewhat, but less than was anticipated. I am now convinced that the problem of securing the banks of the Mississippi River from caving has been solved, but the process under such difficult conditions is probably too costly for very general application, my operations having demonstrated the cost to be about $18 per linear foot; the estimate was made during a period when the work was proceeding favorably.

The conditions here are exceptionally difficult, however, owing to the high velocity of the current, a result of the cut-off.

There remains uncovered about 1,200 feet of bank between the upper and lower work, and 2,300 feet below the lower work. The gap between the detached portions of the revetment has caved rather alarmingly this season, much more than I had supposed. The river there now threatens the Delta depot and railroad terminus. It is highly desirable that it should be protected this fall, but unfortunately the means at hand are insufficient. The caving at the lower extremity of the peninsula has diminished to a marked degree, which is attributed to the revetment higher up, the presence of which partly directs the current from the bank below.

The appropriation made by the last Congress for this work is so small, and the former appropriation so nearly exhausted, that little progress can be made the present season in advancing it towards completion. I can hope to do little more than strengthen weak places and preserve the work already accomplished, until another Congress shall determine whether this work shall be completed or allowed to be gradually destroyed by the attacks of the river, a result which I am afraid will ensue from its uncompleted state.

I will now recur to the subject of the work which it is desirable to do in the harbor proper, to restore and maintain deep water therein.

Referring to the report of General Simpson's Board, in relation to this matter, made in 1878, it will be seen that it was recommended to construct a dike from the south end of De Soto Island across in the direction of the Cotton Compress, to a point about 800 feet from the Vicksburg shore, thence about parallel to this bank down to a point below Ryan's Mill to deep water. This dike would be along the crest of the bar then forming. The next step was to dredge a channel of communication between the shore and parallel dike, from deep water below to the city front, where a basin of sufficient capacity for the commerce of the place should be constructed by the same process.

The cost of these two operations was estimated at $254,000, in addition to the revetment of Delta peninsula.

The developements of the last high-water season show the wisdom of this plan of procedure. The crest of the bar upon which the dike was to have been constructed has now reached an elevation approaching that of the proposed dike, and the effect has been to exclude the inflow of water from the river below, which heretofore passed up by the city landing, and thence around De Soto Island, bringing up with it large quantities of mud and sand, which was deposited in the harbor. There has been since last season no appreciable amount of deposit in front of the town, and as the crest of that bar continues to rise higher from year to year, it is manifest that additional security will be afforded, and the construction of the proposed dike may be entirely dispensed with, saving in that direction the estimated cost of $154,000. The additional amount of dredging, however, rendered necessary by additional filling since the first estimate was made, brings the present estimate up to almost exactly the original amount.

It is now proposed and recommended that a channel be opened from deep water below Ryan's Mill to the elevator building, the channel to be 250 feet wide at the elevator, to be enlarged into a basin 600 feet wide, and extending 1,800 feet along the city front. This should be dredged to a depth of 15 feet below low-water level. The channel of communication will be 4,800 feet long, and the average depth of the excavation will be 26 feet. In the basin the depth of excavation will be 27 feet. The estimated amount of cubic yards of material to be removed is 2,235,555. This is estimated to cost 15 cents per yard, making $335,333.25. It is deemed expedient to protect the side slopes of the excavation by an application of brush revetment, which is estimated to cost $30,000, making a total of $365,333.25 for the whole work. The

operation of dredging would be carried on progressively in different stages of the water, and it is estimated that $150,000 of the above sum could be profitably expended on this part of the work during next season, which, with $100,000 that ought to be applied to the completion of the revetment on the Delta side, will make $250,000, which it is recommended be appropriated for these purposes.

In considering the question of excavating a harbor, it should be borne in mind that there will be an annual silting up to some extent of the mouth of the channel of communication, but it will require but little work at the subsidence of each high-water to keep the mouth open, the cost of which will doubtless be cheerfully assumed by the city of Vicksburg.

This report will be accompanied by a tracing, showing the changes which have occurred in the harbor and vicinity since my last annual report, and the position of the proposed excavation in the harbor.

I have the honor to be, very respectfully, your obedient servant,

T. G. DABNEY,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 22.

IMPROVEMENT OF THE MISSISSIPPI RIVER AND HARBOR AT MEMPHIS, TENNESSEE.

At the commencement of the fiscal year the work upon the protection of the bank along the city front was in course of prosecution. Matters were progressing favorably when, in July, the yellow fever made its appearance, and we were compelled to suspend operations for the summer. In November work was again resumed and continued until February, when high-water put an end to the operations for the season.

Up to the end of the fiscal year some 2,000 feet of bank protection has been applied, and with favorable results. It was unfortunate that we had to suspend operations last summer, as the water in the Mississippi reached a very low stage, and continued so for a long period. Had it not been for the fever we would have made considerable progress.

So far the work has been successful, where applied, in attaining the object in view, viz, the prevention of the bank caving along the city front.

An examination made lately by a diver showed the mattresses still in position along the bank and filled with sediment, and without any caving apparent, except in one instance at the mouth of Wolf River, and this was caused by a flood from that stream when the Mississippi was comparatively low. Otherwise the mattress protection remains intact.

It has this past season been subjected to a severe test, the water having been in a very high stage for upwards of six months, completely saturating the banks; still, when the water declined, no cracks or cavings in the banks were to be observed.

During the coming season it is proposed to continue the work upon the bank protection, and the appropriation asked for for the fiscal year ending June 30, 1882, will be applied to the same purpose.

For the details of the operations I beg leave to refer to the report of Mr. Joseph Burney, assistant engineer, herewith.

COMMERCIAL STATISTICS.

Merchandise and produce sold for twelve months ending September 1, 1879, $66,500,000. Of this amount $19,500,000 was cotton; home produce and home manufacture, $3,200,000.

Amount of cotton received from September 1, 1879, to June 30, 1880, was 405,381 bales.

Number of steamboat landings at Memphis during twelve months, 2,150. Wharfage tax to steamboats, charged by the city for twelve months, $30,000.

The collections at custom-house in Memphis, Tenn., during the year ending June, 1880, are as follows:

Duties on imports	$14,554 23
Hospital dues (marine)	1,853 19
Steamboat inspection	1,590 55
Licenses to engineers, pilots, &c	2,770 00
Total	20,767 97

Population of Memphis is 34,000.

The total estimated cost of this improvement was $170,000.

The former appropriations are as follows:

By act approved June 18, 1878	$46,000
By act approved March 3, 1879	37,000
By act approved June 14, 1880	15,000

Money statement.

July 1, 1879, amount available	$46,825 39	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$61,825 39
July 1, 1880, amount expended during fiscal year		30,323 55
July 1, 1880, amount available		31,501 84
Amount (estimated) required for completion of existing project		72,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		72,000 00

REPORT OF MR. JOSEPH BURNEY, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 30, 1880.

MAJOR: I have the honor to submit the annual report of operations in the protection of the Memphis river front for the year ending June 30, 1880.

In my last report, dated June 30, 1879, I stated "at the present date the working party is thoroughly organized and the work progressing steadily and satisfactorily."

At this time all promised favorably for a good season's work during the low-water stage. We had made favorable arrangements for obtaining stone from the Ohio, and willows, &c., from up the river, tug chartered and flatboats and barges engaged, when the yellow fever appeared in Memphis, July 15, 1879, and we were compelled to abandon the work.

Our orders for stone were countermanded and the workmen discharged. The tools, boats, and outfit, belonging to the government, were towed 30 miles up the river, where they remained until the fever was over.

Immediately after the city authorities officially declared the fever over, work was resumed under very unfavorable circumstances; the low-water season was nearly over and all arrangements had to be made anew. We were considerably delayed in obtaining stone, which had to be brought from the Ohio River, a distance of over 500 miles, and in order to keep the workmen employed until the stone arrived we had to use sacks filled with earth, which are not suitable for sinking the mattresses with; also during the time we were at work the river was steadily rising and had a very swift current.

We had to suspend work temporarily at times on account of high-water and the work was entirely suspended February 19, 1880. Since that date no work has been done except taking care of government property and repairing buildings and mattress ways at the mouth of Wolf River.

The work of protecting the river bank consists in the construction of willow mattresses and sinking them along the river front. The mattresses were constructed as described in my last annual report, and it takes about 40 cubic yards of stone to sink and properly ballast each mattress.

During the past twelve months we have protected 1,300 linear feet of river front. For this purpose we have constructed and sunk 30 mattresses, each 130 by 55 by 2.5 feet. We have constructed on bank, above low-water, 600 linear feet of shore work,

40 feet wide, 2.5 feet thick. This work is constructed, like the mattress work, of willows and poles, but is built upon the bank when the water is at a low stage.

In the work we have used 2,760 cords of willow brush, 7,520 cotton-wood poles, 800 white-oak pins 4 feet long by 1 inch diameter, 6,300 white-oak pins 12 by ¾ inches, 30 coils of No. 12 annealed wire 64 pounds to the coil, 1,154 cubic yards of stone, 1,500 sand bags, and we have driven 50 cypress piles 40 feet long and 1.5 feet diameter.

As the willow mattresses for the protection of caving banks on the Lower Mississippi River have only been used for the last two years, and we are constantly receiving inquiries as to the benefit derived from them, in order to show clearly the result of their use at Memphis, I will give a short history of the work at this point from the commencement.

In 1876 the Mississippi River was fast encroaching upon the wharf and upper river front. In three years, immediately above the foot of Jefferson street, it had caved back over 350 feet, taking in a great many valuable buildings, and was steadily caving at the rate of 100 feet per year. Above Wolf River the caving was at the rate of 150 feet per year. A great amount of valuable business property was in immediate danger of being lost, and no permanent improvement could be made on the river front.

In 1877 you were instructed to make a survey of the river front and submit a project with estimate of cost for its protection. The same year you submitted a report, recommending that the river front from Frames Chute, above Wolf River, to the elevator, at the foot of Beal street, a distance of 7,600 feet, should be protected with willow mattresses from 10 feet above low-water to the bed of the river, at an estimated cost of $170,000. This project and estimate was approved and $46,000 appropriated.

The front to be protected was in two divisions; the first division was above Wolf River and 2,000 feet long; the second below Wolf River and extending along the front of Memphis, being 5,600 feet long. Had the full amount been appropriated as you recommended, it was your intention to protect the upper division first, but as only a small part of the appropriation was made, you determined to begin on the lower division, on which was located some of the most valuable property on the river front, consisting of stores, oil mill, cotton sheds, railroad depot, &c., all in immediate danger of caving into the river. The first place protected was the old navy-yard. Forty years ago the navy-yard formed a part of the Mississippi River and was used for a flat-boat landing, when a sand bar began to form in front of the landing and pushed rapidly out for over 1,000 feet from the old bank.

The sand bar rose to a considerable height above low-water, but has always been subject to overflow at a high stage. Upon this sand bar the United States Government located the Memphis navy-yard, and constructed upon it over $1,000,000 worth of buildings and machinery. Some years ago the yard was abandoned and the ground and buildings given to the city of Memphis. Shortly after the navy-yard was abandoned the river began to encroach upon it, and has carried away over 400 feet, and but for the willow mattresses would soon regain its old channel. In front of the navy-yard from low-water mark to the bed of the river the average depth of water is from 60 to 70 feet, and the rise and fall of the river at this port is 35.75 feet. July 15, 1878, active operations were commenced. We had succeeded in making all necessary arrangements, organized our working parties, constructed work-shops, mattress-ways, &c., and were all ready for sinking mattresses when the yellow fever appeared in Memphis, August 14, and we had to suspend operations until November 7, when the low-water season was nearly over. The work was much interrupted by the rising water and heavy drift-wood, and in January, 1880, the river was entirely covered by floating ice and the work had to be suspended.

Up to June 30, 1879, we protected 675 feet of river front. An examination was made in low-water, with the following result: 800 feet above our work it had caved back 150 feet, gradually growing less to the mattress work, where no caving occurred along the 675 feet protected. Below it had caved a little, and 400 feet below the cave-back was 52 feet. May 20, 1879, the water was at a suitable stage and work was continued as described at the beginning of this report. Up to date we have succeeded in protecting 1,975 feet of river front extending from the mouth of Wolf River to the foot of Poplar street. An examination was made, when the gauge read 14 feet above low-water, and a diver made an examination of the mattresses under water.

It was found that all the mattresses were still on the front, but about four had been moved a little out of position down stream and into deeper water on account of the steep bank on which they had to lie. On the matresses that were first placed down, at their outer ends there was from 3 to 4 feet of solid deposit, while all were completely filled level with deposit. Of the whole bank protected not a single foot has been lost with the exception of 125 feet by 10 feet at the mouth of Wolf River; this was caused by a heavy freshet in Wolf River while the Mississippi was at a low stage. The freshet on striking the Mississippi formed a large whirlpool, which in three days scoured out a hole 70 feet deep from a depth of 10 feet. This carried out to deep water two of our mattresses. Since that time the washout is fast filling up, the bank can be readily repaired, and by revetting the side up Wolf River the danger in future can

be avoided. While there has been no caving on the bank protected on the first division above Wolf River, where no work has been done, the caving has been great; 800 feet above our work the cave for 12 months has been 140 feet, gradually growing less to our work, where the cave is stopped. Thus, in two years this part has caved off nearly 300 feet. Immediately below the work a little caving took place, and 150 feet below the cave is 75 feet. At this point two railroad lines and railroad depot front on the river, and in order to save them from caving in the company drove over 300 piles 40 feet long by 1.5 diameter, at a cost of about $7,000, but so soon as the water fell the bank caved in and is now undermining the railroad depot, while where our mattress work is, about 150 feet above the piles, not the slightest crack or sign of caving can be seen.

Considerable interest has been taken in the work by those interested in protecting the river banks. Some time ago one of our daily newspapers criticized the work, stating that some of the mattresses had floated off, the bank caved in, and willow matresses for the protection of the river bank a failure. This I immediately denied and offered them every facility to make an examination of the work, but this they declined. I then applied to some of our most prominent and practical river men, who had nearly daily seen the work since its beginning, for their opinion of the work. As those gentlemen are all well known on the river, I give a few of the letters received, showing their opinion of the work done on the river front.

LETTER OF SUPERINTENDENT OF THE MEMPHIS AND LITTLE ROCK RAILROAD.

MEMPHIS AND LITTLE ROCK RAILROAD,
OFFICE OF SUPERINTENDENT,
Memphis, Tenn., February 12, 1880.

DEAR SIR: My attention having been called to an article in one of the daily papers of the 7th instant, purporting that the track of the Memphis and Little Rock Railroad having been protected by ripraps had caved in, the mattresses having taken their departure for some points below. I beg to state that no mattresses were ever placed in front of the Memphis and Little Rock Railroad depot at the point where the bank has caved. I am inclined to the opinion that if they had extended that far the bank would have been protected.

Yours, truly,

W. E. SMITH,
Superintendent.

Mr. JOSEPH BURNEY.

I give below letter received from the captains of the harbor tugs:

LETTER OF CAPTAINS OF THE HARROR TUGS.

MEMPHIS, TENN., *February* 11, 1880.

We, the undersigned, have watched the mattress work since its commencement. At first we thought it doubtful, but up to the present time it has succeeded beyond our utmost expectations. We have seen no caving of the bank protected, while rapid caving is now taking place both above and below where it is unprotected.

The statement in the Avalanch that the mattresses in front of the Little Rock Railroad had floated off is untrue, to our knowledge. That point was unprotected; if it had been, we think it would have been saved. We have never seen a mattress float away, and believe that every mattress sunk yet remains in its position.

Any assistance we can render you on the work will be cheerfully given.

W. W. MAINGAULT,
Captain Steamer General Pierson.
N. B. MCNEELY,
Captain Tug Oriole.
L. E. PATTON,
Captain Tug Clarence.
M. R. MCNEELY,
Captain Tug De Soto.

Mr. JOSEPH BURNEY.

I give below letters received from property owners:

LETTER OF MR. R. P. GLENN.

MEMPHIS, *February* 11, 1880.

DEAR SIR: I have been a close observer of your work in placing mattresses on the river front of Memphis, and have felt a deep interest in them. I am convinced they

will accomplish the end in view, as where completed the banks are intact, and where the work has been only partially done a marked improvement is shown.

Where the mattresses have moved at all, it has only been to deeper water, thereby being of more service. But for the one at my warehouse, I am convinced my walls would ere this have fallen in; as it is, the walls, the bank and mattresses are all intact, just as when placed; whereas above, where there are none, the caving is serious, the same as at the railroad.

R. P. GLENN.

Mr. JOSEPH BURNEY.

LETTER OF MESSRS. BROWN & JONES.

MEMPHIS, TENN., *February* 9, 1880.

In the past few years we have lost by caving banks over $30,000. Since the mattresses have been placed in front of our property we have not sustained the slightest injury. We are interested in the work, and have watched it carefully since the commencement, and up to the present time the work has been very successful, and hope it may continue so.

Most respectfully,

BROWN & JONES,
Coal Dealers, &c.

Mr. JOSEPH BURNEY.

LETTER OF UNION COTTON COMPRESS COMPANY.

OFFICE UNION COTTON COMPRESS COMPANY.

DEAR SIR: In answer to your inquiry as to what effect the sinking of mattresses in front of what was formerly known as the navy-yard property, will say, before you commenced the great work, the caving in or washing away of the river front was about 100 feet each year. Your first mattress was sunk on the south side of Wolf River, where it enters into the Mississippi River, and has effectually checked the washing away of the embankment at that point. The river then commenced cutting below the mattresses, but since you have sunk mattresses at that point the caving has ceased. After seeing the good effect of your work, this company built a large warehouse for the shipping of cotton, near the river, which would not have been built if the caving in of the landing had not been checked. I believe the sinking of mattresses will preserve our river front, and if carried out as contemplated will give Memphis one of the best harbors on the Mississippi river.

A. WOODRUFF,
President of Union Cotton Compress Company.

Mr. JOSEPH BURNEY.

As a further proof of the confidence in the willow mattresses for the protection of the river front, action has already been taken to build a union depot for all the railroads running into Memphis, also elevator, and large cotton-sheds, at a cost of over $150,000, on the front we have protected. This would not have been done if the caving had not been stopped.

It will be seen that the work has been done under great difficulties. We commenced in the middle of the caving front and had to protect a sand bank readily susceptible to the slightest scour, and the work has been twice interrupted by two of the worst epidemics that have afflicted the South. We have never been able to work through a low-water season, yet the work stands as if it had been done under the most favorable circumstances. The only difference is, if we had not had those difficulties to contend with, we could have protected more river front and at a less expense.

In your report made in 1877, you state: "The work, if once commenced, should be continuous." This is very important, as we are in the center of the caving front, and from the great caving above and below, if the work is not pushed vigorously on to the end, it will endanger the work already done. I would respectfully recommend that the amount required to complete the work be applied for, and I believe when the work is completed, Memphis will have the best harbor on the Mississippi River.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 23.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

Observations were continued at all the gauges during the year. Repairs were made upon those at Memphis, Tenn., Helena, Ark., mouth of White River, Ark., Lake Providence, La., Natchez, Miss., Red River Landing, La., and Alexandria, La.

Owing to the yellow fever in 1878 and 1879, and the strict quarantine maintained during the low-water season, it was found impossible to have the necessary repairs done that were intended, the principal part of the work being done at a high stage of water. It is proposed during the low-water of this year to make a thorough examination of the gauges, to construct new ones where required, and to place them all in good order.

At Alexandria, La., the standard low-water has been changed from 1872, 2.60, to 1879, 3.10.

At Little Rock, Ark., the standard low-water has been changed from 1864, 0.00, to 1879, 1.00.

Hydrographs were made of all the gauges, but retained in this office.

Copies of the gauge records at all the stations for the year are transmitted.

Money statement.

July 1, 1879, amount available	$5,320 70	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$10,320 70
July 1, 1880, amount expended during fiscal year		3,404 42
July 1, 1880, amount available		6,916 28
Amount that can be profitably expended in fiscal year ending June 30, 1882		5,000 00

O 24.

SURVEY OF THE FALLS ON RED RIVER, NEAR ALEXANDRIA, LOUISIANA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1879.

GENERAL: I have the honor to transmit herewith the following report of the survey of the falls of Alexandria, La., with estimates for the improvement of the same, made in accordance with the act of Congress approved June 18, 1878, and assigned to me by letter under date of July 8, 1878.

So long back as 1840, the State of Louisiana had taken the subject of the improvement of the falls of Alexandria under advisement, and appropriations were made at various times for that purpose. The work accomplished consisted mostly in the removal of portions of the rocky barrier constituting the upper and lower falls, of supposed sufficient width and depth to allow for the passage of the largest class of boats navigating the river.

While many of the most valuable reports of the State engineers upon the matter cannot be obtained, the board of State engineers of Louisiana, in their special report, in January, 1874, present abstracts from

such as could be collected which tend to give a history of the various attempts made to improve the locality.

As they have an important bearing on the subject, as showing the views entertained as to what was considered the best methods of improvements, I will quote the extracts in their order as taken from the report referred to.

In Dunbar's report of 1840, he says, in regard to the falls at Alexandria:

The next and greatest obstruction to the low-water navigation is the falls at Alexandria. This obstruction consists in a fall of three feet, at low-water, above Bayou Rapides, with two rapids one mile above, having a fall of one foot. The rock forming the bed of the river consists of an extremely soft and friable sandstone slightly impregnated with marl. The stone yields readily to the knife or any hard body, and may be crushed by the finger.

About fourteen hundred feet above the lower falls the channel divides, one (the main channel) running over to the eastern and the other keeping close to the western shore. In a choice as to which of the two channels should be cleared I had to consider two things—first, the comparative expense of the two, and, second, the beneficial results to be produced. If we cut the eastern passage, we take the one chosen by nature, and, in this instance, the most proper. If the western, we throw the whole force of the current against the banks upon which the town is built, and might cause the destruction of a large portion of the town. The expense is in favor of the eastern channel, and I shall accordingly make my estimate for it. The profile shows the section of the bed of the river, with the bar or beds of rock which it will be necessary to remove. The estimates are made for a channel sixty feet wide, with depths of six and eight feet.

Dunbar considered the passage giving a depth of eight feet of water over both falls as preferable, and so recommended it, the estimated cost being $28,000.

It seems, further, that the legislature made an appropriation for the work, but nothing whatever was done, as it seems that Dunbar feared that the removal of the barrier would injure the navigation above. He says:

I desire to submit this matter again to the consideration of the board and to the legislature, and I was impelled to this course from a fear that when these obstructions were removed at the point where they now exist new ones of a similar character would present themselves at a point higher up the river. Such is the opinion of many persons with whom I conversed on the subject, and who, I am inclined to think, have a good knowledge of the river. A fear that their opinion might be correct, and that the expenditure of this heavy sum, appropriated at a time when our State was so much embarrassed by its pecuniary responsibilities, might be made without a corresponding benefit, induced me to incur the responsibility of postponing the completion of the contract; and I was strengthened in the propriety of this course from the fact that no injury could result from this delay, for the reason that the work can only be done when the water in the Red River is low. I now submit this matter to the legislature and yourselves for new instructions.

In 1852, A. D. Woolbridge says:

A canal or channel should be cut 50 feet wide through the falls at Alexandria, and all the water thrown into said channel by walls laid in cement upon the rocks, across the balance of the river. I am convinced were this done that the present amount of water passing over the falls would give from 5 to 7 feet depth in this channel, without in the least lowering the water above. In fact, that we should have better water in this channel than we now have on the bars above and below. The bars in Red River cannot be removed. They are composed of quicksand, with one or two exceptions, and are constantly shifting with every stage of water, and with every accidental change of the current. In many places the only practicable channel is obstructed by fallen timber or snags. Were all these removed, at the lowest stage of water the navigation would be vastly improved, and perhaps never entirely suspended.

In 1853, in the report of George W. Morse, State Engineer, we find:

I have thought it quite unnecessary that I should make a survey of the falls near Alexandria, in accordance with act No. 80 of the last legislature, as the work of removing the obstructions, I know, was going on under the superintendence of Colonel De Russy, the able engineer appointed by the commissioners. I presume that after

the examination and surveys which he has made, he will be able to demonstrate the utility of the work now in progress.

A stream which already brings to market about 300,000 bales of cotton, while its resources are not half developed, one-half of which at least pays one dollar extra on account of the obstructions, without counting the extra cost of transporting other articles, is worthy of the very best improvement which can be adopted.

It seems from this report that a contract had been made with Messrs. Maillefort & Raslorff, of New York, for the removal of a portion of the rock, with what success is shown by the following report.

In 1854, George W. Moore says:

It is probably my duty as State engineer to call the attention of your honorable body to the present situation of the falls in Red River at Alexandria, and to the generally bad condition of that stream. Commissioners were appointed and money appropriated for the removal of the falls by an act of the legislature, approved March 11, 1852. In the summer of 1853 an attempt was made to blast them out by Messrs. Maillefort & Raslorff, of New York, which certainly did not improve the condition of the river, and last year nothing was done, notwithstanding an additional appropriation was made for that purpose. It is high time that a stream which now brings to market nearly one-eighth of the cotton crop of the United States, and which will be doubled in the next ten years, should be relieved of such an embarrassing impediment to its navigation. I have not yet seen any reason to change the views expressed in my first annual report in reference to the necessity of locks at this point, except as to their location. I have had a good opportunity during the last summer to make examinations of the rock, and have such samples in my office as will show clearly its character, from which I judge that a crane properly arranged for dredging, and attached to one of our heaviest State boats, would without difficulty excavate the required channel through it. The rock at the falls, when wet, can be easily cut with an ax or a crowbar, and if the spoon attached to the crane should meet with any hard substance which it would be unable to remove, it could be dislodged with powder or a falling bar of iron. My examinations have convinced me that there is room enough on the north side, in the bed of the river, between the hill and the low-water, in which to place a lock, which I would propose to construct partly of the hardest portion of the rock, and the rest of cast iron, the gates of which to be high enough to hold the water 2 or 3 feet above low-water mark only, so that when the river was up they should be open and entirely covered. Such a lock would not be very expensive if the excavations could be made with a dredgeboat, particularly as with her crane she would deposit the earth on the outside, so as to form a coffer-dam in the shallow water, into which a part of the basin might run. This impediment costs the State, in advanced prices of freight, not less than $300,000 upon an average per year, and less than one-half of that sum would remove it. A lock here, and wing-dams in a few other places, and light-draught boats could at any time navigate the river from its mouth to Shreveport. There is always plenty of water, and all that we require besides the lock is to confine it. The importance of the stream demands more energetic appliances of improvement. The low-water of 1850 and 1854 should not discourage, but rather stimulate our exertions; for a judicious expenditure of a sufficient sum to construct 20 or 30 miles of railroad would carry us through to Shreveport on 3½ feet water at any time without difficulty; and during an ordinary low-water season, such as has been experienced at any time, except in the years 1850 and 1854, we could easily obtain 4 feet. Our State boat, the Governor Hébert, went to Alexandria on the 23d of December, 1854, at the very time when the water was lower than ever before known, and we are sure that she draws 3½ feet. While the State is expending millions upon railroads, why should it not employ four or five hundred thousand dollars to properly improve the navigation of this great river, which must, even after the completion of the roads, continue to carry to market nine-tenths of the produce of the valley, even if left in its present condition?

From report of Louis Hébert, State Engineer, 1856:

Nothing has been done, I believe, during the year, upon the falls at Alexandria. In my annual report I strongly recommended the construction of locks upon one or the other falls. I must here repeat my recommendations. Nothing else will do; and the large commerce of Red River (large even now, and increasing so as to be at some day almost incalculable) warrants any outlay, even to millions of dollars.

He next takes into consideration the project of rendering the Rapides and Jean de Jean a canal of circumnavigation around the falls, and proves that four locks would be necessary in each stream, and estimates that each lock would cost no less than $35,000.

The rise of Red River in 1849 being 41 feet above the low-water of 1856, the locks would not prevent the overflow of the Rapides country

From the reports of the various State engineers it will be seen that the following methods of overcoming the obstructions have been proposed:

To build a lock and dig a canal around the falls.

To open and enlarge the Bayou Rapides.

To remove the falls or cut a channel through the rocks.

To contract the water-way by wing-dams.

The only attempts made, however, to improve the falls consisted in cutting away a portion of the top, and also cutting a channel through the rocks.

In May, 1864, the fleet under Admiral Porter operating with the army under General Banks was caught by the low-water above the falls, and was extricated from its perilous position by Colonel Bailey, engineer of the Nineteenth Army Corps, who built a dam across the lower falls, and wing-dams upon the upper.

The greater portion of Bailey's dam is still in existence. The old channel left by him through the middle of the structure is still open, but the river has, however, worked around the east end, causing a considerable erosion of the banks above Alexandria, and making a channel sufficiently wide and deep as to constitute the main channel of the river.

In 1874 Congress directed a survey of the falls to be made with a view to the improvement of the locality, and the work was assigned to Major Howell, whose report will be found in report of the Chief of Engineers for 1875, page 902 *et seq.* The report is very exhaustive of the subject and discusses the various projects entertained for the improvement, and recommends the building of a dam at the foot of the upper falls, with a lock and navigable chute, the estimated cost being $97,652.99. For full details of the project, reference may be had to Major Howell's report as above.

In the survey made under my direction by Assistant Engineer W. M. Rees, Major Howell's map was taken as a guide, and the tracing herewith is from that map, with additional soundings and cross-sections. The character of the rock forming the falls is such that no change could result from the action of the water, and the channel over the upper falls is still in the same condition as above reported. The additional soundings and references are noted in red; those of the old are in black. In addition also to the discharge observations I caused a survey of the river to be made extending up to Colfax, twenty-five miles above, with separate surveys of the various shoal places at present existing.

The government is at present undertaking the improvement of Red River from Fulton, Ark., to the mouth, in the removal of what may be termed accidental obstructions, such as rafts, snags, &c.; also the closing of Tone's Bayou; also the improvement of the mouth, which latter is at present under consideration, as it interests not only the navigation of Red River and its tributaries but also the Atchafalaya and its connecting network of navigable channels and bayous.

Nothing yet, however, has been attempted in the way of the improvement of the various bars and shoal crossings now interrupting navigation, but which will be attempted so soon as sufficient appropriations are made to carry on such work. The improvement of the falls must necessarily constitute another work, a part of whatever plan may be adopted for giving good low-water navigation in Old River.

Now regarding the depth required for navigation, Major Howell, in his report, states that—

The depth of the channel over the upper falls (3 feet) would be sufficient at extreme low-water for such vessels as can engage in the low-water trade of Red River, if it

were not for the narrowness of the channel, its abrupt turns, the velocity of the current through it, and its rock bottom.

The statement as to the sufficiency of depth is based on information gained from steamboat men who have for years been engaged in the Red River trade, to the effect that during two months of each year they count on only 2 feet; for two months more on only 3 feet; and for the remainder of the year on excellent navigation from the Mississippi to Alexandria. From Alexandria to Shreveport, during extreme low-water, a draught of 2 feet may be carried, with considerable difficulty, over sand bars affording a depth of water of only 20 inches.

When there is 5 feet of water over the upper falls, 8 feet may be carried from them to Grand Ecore, and 6 feet to Shreveport.

Information from the same parties was to the effect that, with the water in the river at Alexandria 3 feet higher than at the time of survey, boats suited to low-water navigation of the river are able to pass the falls without trouble. Three feet higher would make the reading on the United States gauge at the beginning of this navigable stage $\frac{37}{100}$ above zero.

On this latter point my gauge at Alexandria shows that from 1872 to 1879 there were the following number of days upon which the gauge reading was below $\frac{37}{100}$, and that consequently the navigation over the falls might be considered as virtually suspended—

	Days.
1872.	
September	13
October	31
November	30
December	19
Total for 1872	93
1873.	
September	9
October	15
Total for 1873	24
1874.	
August	13
September	30
October	14
November	21
December	17
Total for 1874	95
1875.	
July	7
August	10
October	7
November	28
December	10
Total for 1875	62
1876.	
September	3
October	31
November	30
December	31
Total for 1876	95
1877.	
January	23
August	16
September	30
October	22
Total for 1877	91

1878.	Days.
October	28
November	30
December	8
Total for 1878	66
1879.*	
June	2
July	31
August	31
September	30
October	31
November	30
December	20
Total for 1879	175
Total from 1872 to 1879, inclusive	701

The water in Red River since the survey this year has been lower than ever known before; my gauge at Shreveport, showing a stage 3.5 below the low-water of 1878, and 2.5 below the low-water of 1872. At Alexandria it was .5 lower than 1872, or 3.1 below the zero of the gauge at that place. From Alexandria to the mouth not over 20 inches of water could be found upon the great majority of bars.

As before stated, as the government has undertaken to improve the navigation of Red River, the improvement of the falls must necessarily be taken into consideration. If it be found necessary to provide for the passage of the upper falls by a dam with a lock and navigable chute, that proposed by Major Howell I deem the best under the circumstances, requiring, however, an enlargement of the lock for the size of boats that could navigate the river when there is a 5-foot stage of water, for we find among the boats the Laura Lee, 210 feet long; Kate Kinney, 200; and the Jesse K. Bell, 225.

In considering the method of improvement by cutting a channel through the upper falls, I do not think that the danger of draining the pond above or injuring the navigation of that section of the river need at all be apprehended. The obstruction acting as a dam, the back-water proportionately increases the depth over the bottom and tends to improve the navigation above, but Red River being a sedimentary stream, the check given to its current by the back-water causes the sediment to be deposited throughout the entire distance of the retardation, and it is possible that the falls shoal rather than deepen the water above. Upon the removal of the obstruction the alluvial deposits would all be washed out by the increased velocity of the current.

The survey made by Mr. Rees shows that the average fall from Colfax to the head of the upper falls, a distance of 24 miles, is .267 foot per mile, with 5 shoal places in that distance, the only rocky formation found being De Loche's rocks, about 5 miles below Colfax. These, however, project from the bank, and there is a good depth of water in the river at that locality.

The length of the upper falls is 935 feet; with a total fall (low-water slope of 1874) of 2.5 foot.

The length of lower falls is 500 feet; total fall (low-water slope of 1874) is .5 foot.

Intermediate reach, 4,565 feet; (low water slope of 1874) .5 foot.

As it is not contemplated to cut away the entire ledge to a sufficient depth for navigation purposes, but only a channel sufficiently wide for

* Not yet completed.

the passage of a steamer and loaded barge, the lowering of the slope above I do not deem will be sufficient to affect the navigation, and the increased velocity will not be great enough to cause any great additional trouble to the steamers.

For the upper falls it is proposed to take the line shown on the tracing herewith along the eastern shore, and excavate a channel so as to obtain a width of 75 feet, and a permanent depth of 4½ feet below the plane of low-water of 1874; as at this latter stage there was a scant 3 feet over the upper falls, the bottom of the cut would give, say, an average additional cutting of 1½ feet. In the proposed cut it has been the aim to take advantage, as far as possible, of existing depth and channel direction. The total length of the cut is 1,150 feet.

On the lower falls it is proposed to build a dam with the rock taken out of the cut above, from the point above the cutting on the Alexandria side over to the end of the Bailey dam, and allow the old channel through the dam to become the new one. The raising of the water surface above the lower falls by this improvement will tend to diminish the fall caused by the cut through the upper falls.

The estimated cost of this improvement, excavating 5,626 cubic yards of rock, with coffer-dam, &c., and building dam, is $39,945.60.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 25.

EXAMINATION OF YALLABUSHA RIVER, MISSISSIPPI.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1879.

GENERAL: I have the honor to submit the following report upon an examination of the Yallabusha River, Mississippi, provided for by act of Congress approved March 3, 1879, and assigned to me by letter of April 25, 1879.

The examination was made by Mr. W. M. Rees, assistant engineer, whose report will be found annexed, and was made with a view of determining the character and extent of the obstructions to navigation, with estimated cost of removal, and the nature and extent of the commerce to be benefited.

The Yallabusha is a small stream (estimated to be about 90 miles in length), and has its source in Calhoun County After flowing through Grenada and Le Flore Counties, it unites with the Tallahatchie and forms the Yazoo River. The examination shows that, like all the streams in that section of the country and in the Yazoo basin, the main obstructions to navigation are snags, sunken logs, and leaning timber, the removal of which constitutes the principal work to be carried on with a view of improving the navigation of the stream, and of giving increased facilities for the shipment of cotton, and the return of plantation supplies, and other freights.

The country through which the Yallabusha runs is very sparsely settled, and in a number of places the land adjoining the river is inundated

at a high stage of water. The shipments are mainly from the plantations back from the river.

Under the present condition of affairs, Grenada is the principal shipping point, from which place, annually, the amount of cotton shipped is estimated at 12,000 bales. The greater portion of this finds its way by rail to New Orleans. The shipment by river last season amounted to 3,000 to 3,600 bales. Were the river improved, no doubt the greater portion that now goes by rail would find its way out by boat, and at reduced rates of freight.

In the present condition of affairs it is deemed only necessary to cut down the leaning timber and remove the rack heaps and the most dangerous snags. For this purpose no snagboat is necessary. During the lowest stage of water a party can be sent along the river with the necessary tools, &c., and everything can be cut out.

The estimated cost of this improvement is $7,000.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. MARSHALL REES, ASSISTANT ENGINEER.

MEMPHIS, TENN., *December* 11, 1879.

MAJOR: I have the honor to submit the following report upon an examination of Yallabusha River, Mississippi, made under instructions received from you December 2, 1879:

On December 3 I proceeded, with a skiff and two experienced skiffmen, to Grenada, Miss. December 4 and 5 being rainy, I started down the river on the 6th and reached its mouth on the 8th, a distance which I estimate to be about 90 miles.

The Yallabusha River has its source in Calhoun County, and, flowing through Grenada and Le Flore counties, unites with the Tallahatchie, to form the Yazoo River, at a point four or five miles above Greenwood, Miss., and about 260 miles from the mouth of the Yazoo.

Five miles above Grenada it receives a large tributary from the right and north side called Schooner River, and immediately above the town another large tributary called Bogue Creek comes in from the left side. Between Grenada and the mouth there are several small tributaries, nearly all on the right and north side. Before leaving Grenada I made inquiries from prominent citizens both as to the navigation of the river and the trade and resources of the adjacent country.

During the winter of 1878-'79, three boats, of from 600 to 800 bales (of cotton) capacity, reached Grenada, one boat making three trips, or, in all, five to six trips, which, at 600 bales per trip, gives from 3,000 to 3,600 bales carried from this region last year by steamboats. The total amount of cotton then shipped from Grenada was 12,000 bales, and had the boating facilities been sufficient fully one-half would have been shipped by boat. The boats also bring up supplies (provisions, &c.).

Prior to the late war, boats of 1,200 to 1,500 bales' capacity reached Grenada, which place has generally been considered the head of steamboat navigation. Keelboats carrying 300 to 400 bales have run as far up as Graysport, 12 miles above. The railroad bridge crossing the river at Grenada is a bar to navigation above.

The country through which this river runs is sparsely settled near its banks; in most places the land is subject to annual overflow, in part caused by back-water from the Yazoo River. The overflowed district extends from ½ to 1 mile inland, where hill or rolling country is reached, much of which is settled, producing principally cotton.

At about 30 or 35 miles below Grenada the hill country ends, and from thence to its mouth the river flows through a flat, bottom country for 60 miles, nearly all of which is overflowed almost annually for miles back from the river.

Along the entire portion of the river examined I counted 10 clearings and six or seven steamboat landings. As the river was reported to be about four feet above low-water when I left Grenada, I was not able to determine the obstructions in the channel with as much accuracy as I would wish. During my trip down, the river was

slowly rising. The rise at Greenwood on Yazoo River was reported to me as 5 feet above low-water on December 8.

I learned from several sources that in extreme low-water numerous snags are shown, making the river in many places impassable to a skiff. With the river 4 feet above low-water I counted 150 snags in the channel, besides ten or twelve rack heaps (three or four of the largest being about 25 by 50 yards, and occupying about half the width of the river). A considerable number of the projecting snags appeared to be branches of trees which had fallen in the channel; many can be readily removed by cutting up during low-water.

For about forty miles below Grenada the banks have been cleared of overhanging trees. This work was done during the past summer at an expense of $600, paid by the county of Grenada.

Four years ago the grangers' society expended several hundred dollars on similar work. Much of the timber and brush cut last summer is lodged in the river, the greater part of which will, I think, go off during high-water.

On the lower fifty-five or sixty miles there is considerable overhanging timber, forming obstructions to navigation; they are oak, willow, sycamore, and some few cypress, mostly of medium size. Both banks of the river from Grenada to the mouth are covered with timber; the greater portion of that suitable for lumber is oak, of which there is a large quantity. At a few places where the bluffs reach the river, pine is seen. Near the mouth is some cypress.

The width of the river at the present stage of water is from forty to sixty yards, in a few places, nearer the mouth, reaching seventy to eighty yards.

The banks to a height of ten or twelve feet are in general steep, caving but in a few places. Owing to the rapidity with which the water falls at times, boats risk running to Grenada only during high-water (six to ten feet above low-water). At the present stage (four feet) there is a good current. I estimate the velocity in the channel at from two to three feet per second, or one and a half to two miles per hour. The country passed through is alluvial with more sand in the upper part, producing from one-half bale of cotton in the uplands to one bale per acre on the bottoms.

A part of the hill lands is much broken by ravines and gullies, caused by the rain-waters, thus making a considerable portion unfit for profitable cultivation. Much of the hill lands are said to be very inferior cotton lands.

The freight rates on cotton from Grenada to New Orleans are, via railroad, $3.50 per bale; via steamboat last winter, $2.50 per bale, and when improvements are made in the river the steamboat lines agree to carry cotton to New Orleans for $2 per bale; the latter is the present price from Greenwood on the Yazoo.

In conclusion, from lack of definite knowledge concerning the river during low-water, I do not feel justified to recommend its improvement for permanent navigation. Still I am of the opinion that a small sum can be profitably expended to remove such obstructions as will insure the safe passage of boats during at least four months of the year, which time the water is said to be three or four feet above extreme low-water; such improvements to consist in the cutting of overhanging trees and the removal of rack heaps, and the most prominent snags, thereby insuring navigation to small boats. I therefore recommend, as the amount that can be profitably expended, the sum of $7,000.

Very respectfully, your obedient servant,

W. MARSHALL REES,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

O 26.

EXAMINATION OF TCHULA LAKE, MISSISSIPPI.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., December 20, 1879.

GENERAL: I have the honor to make the following report upon the examination of Tchula River (or lake, as it is called), Mississippi, with a view to the improvement of the same, in accordance with the act of Congress approved March 3, 1879.

Having the snagboat Meigs in the Yazoo and in the vicinity of Tchula Lake, I directed Captain Straszer to make the examination of the stream.

From his report, and from information received from the Mississippi and Yazoo River Packet Company in regard to the commerce of the stream, sufficient information has been obtained upon which to estimate for the improvement.

When the Yazoo reaches the head of Honey Island, it divides itself into two branches—the westerly one retaining the name, the Yazoo, while the easterly and narrower branch is named Tchula Lake or River. The distance from the head to the foot of the island, where the two branches again unite, is about 80 miles.

In the lower river, the distance between banks is about 125 feet, narrowing to about 80 feet proceeding up towards Tchula City, about 40 miles distant from the foot of the island. From Tchula City to the head of the island the width between banks varies considerably, being very narrow for the last few miles. It is only during the existence of a moderate stage of water that boats are enabled to enter and navigate this narrow channel.

The principal obstructions to navigation consist of a number of sawyers and cypress logs in the lower part of the river, and leaning timber all the way from the foot to the head of the island on both banks; also logs stretching out from the banks, some of them partly cut off.

The country along the river is highly cultivated, and very productive plantations join one another. The amount of cotton raised is estimated at about 20,000 bales, about one-half of which is brought out through the lake when there is sufficient water for navigation, and the remainder is hauled to the Yazoo, where there is navigation all the year round. Were Tchula Lake improved, so as to admit boats of a light draught to enter earlier in the season, no doubt the greater portion of the crop would come out by that channel.

The work of improvement will consist in the removal of the snags, cutting off the outcropping logs, and felling the overhanging trees.

As the work could all be done in one low-water season, I do not deem it necessary to provide a special outfit therefor, but to charter a light-draught steamer with the necessary machinery, &c., such as I had on the Sunflower last season, and operate with her.

The estimated cost of the work is $10,000.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O 27.

SURVEY OF THE MISSISSIPPI RIVER NEAR LAKE CONCORDIA, LOUISIANA, AND COWPEN BEND, MISSISSIPPI, LOOKING TO THE PROTECTION OF THE HARBORS OF NATCHEZ AND VIDALIA.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., February 17, 1880.

GENERAL: I have the honor to transmit the following report upon the "survey of the Mississippi River near Lake Concordia, Louisiana, and Cowpen Bend, Mississippi, looking to the protection of the harbors of Natchez and Vidalia," as provided for by joint resolution approved June 28, 1879, and assigned to me by letter from the department, under date of July 25, 1879.

Immediately upon the receipt of the instructions the necessary arrangements were made to commence the survey at the earliest practicable date, so as to take advantage of the then approaching low-water season as affording better facilities for the prosecution of the field-work. The party was organized and work was started on the 8th of August, under charge of Mr. W. C. Melvin, assistant engineer, whose report is transmitted herewith. The field-work was finished October 8, though somewhat delayed in the earlier stages by quarantine regulations and by malarial fevers among members of the party.

The survey along the Mississippi River extended from Rifle Point to Arnolia Landing, below Vidalia, a distance of about 15 miles, with various cross-sections of the river, levels, soundings, and borings. It embraced also both arms of Lake Concordia, the head of Bayou Cocodrie, and the adjacent country. It was made with a view of determining the danger which at present threatens the destruction of the harbors of Natchez and Vidalia by reason of the possibility of the Mississippi cutting through Giles' Neck and also into Lake Concordia, and to present plans with estimates for the prevention of the same.

From the map it will be seen that, after leaving Rifle Point, the Mississippi, turning westwardly (Giles' Bend), sweeps around Marengo Bend, and returning almost upon itself takes another turn around Cowpen Bend, at the lower extremity of which is situated the city of Natchez. The distance around the Bend is about 9 miles, while across the neck of land, from Giles' Bend to Cowpen Bend, the distance (as measured at the close of the survey) was but a little over 6,000 feet. In 1858 it measured 3 miles. This neck of land is becoming more and more narrow each year from the constant caving, due to the eroding action of the current on both sides, though particularly on the north, or in Giles' Bend. The rapidity with which this caving has taken place lately may be judged from the fact that during the survey, from the 20th of August to the 7th of October, the bank on that side had caved away in a straight line 394 feet. Should the river cut through this neck (and the possibility is that it will do so at no great future time), it will cut away the Natchez bar and the point of land on which Vidalia now stands, which will be followed up by the formation of a bar on the opposite side and in front of Natchez.

The caving in Giles' Bend extends from the light-house post at the head of the bend to Dunham's Bar at the foot; this caving being greatest about the middle point, where it is constantly going in by a gradual sloughing, with a movement almost imperceptible to a casual observer. The length of the bank caving is about 3 miles.

The caving on the opposite side, or Cowpen Bend, commences about half a mile below Dunham's Bar and continues down below the Natchez light-post, the measured distance being about 3 miles. The heaviest caving is from the mouth of the small bayou that drains Giles' Neck down to the light-post. This neck of land I consider the most important in connection with the protection of the harbors, and is the first point to which any remedy should be applied looking to the protection of the water fronts of Natchez and Vidalia.

There seems to be some apprehension that the Mississippi will cut into Lake Concordia. This arises from the caving taking place around the entire length of Marengo Bend, from the foot of Rifle Point Bar to the head of Natchez Bar, a total distance of about 7 miles. At two points the caving goes on by constant and gradual sloughing; the first, at the old inlet to Lake Concordia, at Bullitt's Bayou; the second, 1 mile below, at the old bed of Grassy Lake. All the other parts of the bank

cave upon a falling river, when the different strata of sand composing the bank have been washed out, causing the superincumbent mass to tumble into the river.

The caving is due to the eroding action of the Mississippi current, which, after leaving Giles' Bend above, crosses to the Louisiana shore and runs with its greatest force along the upper part of the bend, particularly at the old head of Lake Concordia. The distance from the inner bank to the lake here is about 800 feet. There is some possibility of the river making its way through the lake again at this point at high water. It is more probable that in the event of continued caving the high-water will pass through the low grounds near the old track of Bullitt's Bayou toward the Marengo swamps, and into the lake at the Waterloo and Marengo breaks, this course being much the shorter.

The bank has caved in the vicinity of Bullitt's Bayou in the past three years upwards of 1,800 feet; about a mile and a half below the average caving up to last year was about 800 feet a year for several years past. Last year it showed quite a decrease in the rate, and seemed to be checking up. The remainder of the bend has been caving, but seems to be on the decrease.

Should the caving continue in the middle of the bend, there seems to be some danger of high-water also going through the low land at that part of the willow swamp known as Grassy Lake. It would be in the immediate track of the water from several crevasses that have occurred in the levees since 1860. The cross-sections show the extent of the damage by washing and the facilities created for a rapid flow from the river to the break at this point. This water would flow into Bayou Cocodrie, which leads out from the south arm of Lake Concordia into Black River some few miles above its junction with Red River, and would tend to keep the Black and Tensas rivers continually in an overflowed condition during high-water in the Mississippi.

The danger to be apprehended from the river cutting into Lake Concordia I believe to be overestimated. At high-water it would, as stated, overflow the Black River swamps through Bayou Cocodrie. This could be remedied by damming this bayou at its head and building a levee from thence to Rifle Point levee along the south arm of Lake Concordia. The height of this levee would be about 5 feet, and the total length about 9 miles. The tendency of the flood-waters would be to fill up the lake from the deposition of sediment, while, as the waters receded, the tendency would be to drain the greater part of the lake.

For the protection of the harbors of Natchez and Vidalia, it is recommended that the remedy be first applied to the caving bank in Giles' Bend. Instead of any system of spur-dikes, &c., I would propose to revet the caving bank with brush and stone, such as has been applied to other caving banks on the Mississippi River. The length of the caving bank in Giles' Bend needing protection is 15,800 feet.

The length of the bank needing protection around Marengo Bend is about 7 miles, a long distance, and therefore must necessarily be expensive. It is proposed to adopt the same method of protection as in Giles' Bend.

As the opposite side of Giles' Neck, that is, Cowpen Bend, is not caving to such an extent as to warrant any apprehension of serious damage to the harbor of Natchez at the present time, it is not deemed necessary to recommend any improvement of that bank immediately, but await the result of the work in the bends above. It is possible that at some future time work may have to be continued along this bend also.

ESTIMATES.

For protection of Giles' Bend with brush and stone revetment, 15,800 feet, at $18 per foot	$284,400
For protection of Marengo Bend with brush, &c., about 36,400 feet, at $18 per foot	655,200

The maps are not all finished yet, but I deemed it best to forward the report in time for action.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. W. C. MELVIN, ASSISTANT ENGINEER.

SIR: I have the honor to submit a report of my operations in and near the Natchez Harbor.

I commenced work in the field on the -th day of August, 1879, having brought with me, from New Orleans, H. K. Hodges, assistant engineer, as leveler; Hiram Henry, rodman; Charles O'Dowd and Frank Walgamoth, as chainmen; John Hodge, boatman; and Richard Concry, as camp cook.

On arriving at Natchez I found we would not be permitted to land anywhere near the town, or to hold communication with its inhabitants, and I fixed camp at Bullitt's Bayou, it being about the most central point for work. I ran a base-line north 4° 55' east from a stake set on the top of Marengo levee, 43 feet from the brink of the river bank, across the Mississippi River to Dunham's Bar, to the bank of the river again, the line being 12,750 feet from Station 0 to Station 1. The line continued south 4° 55' west, from 0 to the south bank of Lake Concordia, 3,873 feet. This line forms a base-line for all work and divides it into an east and west division. The lines of traverse all start from this line; the level lines also. The east line starts from Station 0 and runs down the river to Station 44, near the Arnolia gin house, below the town of Vidalia, and the end of the survey down stream.

The west line starts from the same station, 0, and runs up stream to Bullitt's Bayou at Station 62; then across the head of Lake Concordia, to Good Hope road; then recrossing an arm of the lake to Vidal's Island, and down the north side of the island to Sahara Ferry; and crossing the south arm of the lake again connects at Station 28 of south bank lake line.

On the land lying between the river and the lake, many lines were run for topographical purposes and location of some of the more prominent sloughs and bayous, and to determine the extent of the swamps.

Several lines were cut, to make accurate cross-sections from the lake to the river at points at which the river will, if not checked, go through to the lake. The most notable is the line from the Waterloo break to Station 32, west line. These lines, as in fact almost all of my work, were a tiresome distance from camp, and I deemed it economy to employ a wagon and team for carrying us back and forth. I could use our own skiff for some of it, but not all.

Mr. Hodge's death was a drawback on the progress of the work. It seemed at the time that the whole of my party from New Orleans would be down sick. The two colored men, Hodge and Concry, I was compelled to send back, one of them (Concry), I learned since, died of malarial fever; Walgamoth is also still sick with the same disease in New Orleans; add to it all the rains and quarantine, I was under many disadvantages. On the 5th of September I engaged Captain Adams, of Natchez, to take the place of Mr. Hodge. He has been with me all the time since, and very satisfactorily performed the duties.

On the 14th of October, having no longer any use for them, I discharged Hiram Henry, rodman, and all of the axmen and flagmen, and retained in camp O'Dowd, Doherty, and Brewerton, and the cook, Phil. Cunningham.

After a brief history of the operations, as above reported, it is proper to give you a statement of general features of ground and river embraced in this survey, commencing with Giles' Bend and Swamp, both occupying a very important place in any future work that may be done in connection with the improvement of the Natchez and Vidalia harbors. The bend is on the Mississippi shore, and forms the river bank, curving around Rifle Point Bar, and ends at the up-stream end of Dunham's Bar, in front of Giles' Swamp; and that you may the better understand the position of both bend and swamp, I will commence at the lower part of it.

At a point bearing north 30° 50′ east, from Light-Post Station 21 east line, to stake on top of bank, on a line bearing north 15° west, across Giles' Swamp to Giles' Bend is 6,408 feet from bank to bank. The same line, if measured in 1858, would have measured a little less than three miles. All the changes have been at the north end of the line, and the river is to-day passing over the same bed that it did fifty years ago. The cotton-wood trees growing on both banks are abundant proof of this. The neck of land that this line crosses is called Giles' Swamp, and the bend it starts from is Cowpen Bend.

The appearance of the soil has all the appearance of the slow filling up from slow moving water from the Mississippi River, depositing fine sand and vegetable decomposition, and is extremely friable. The more north we go the greater evidence we find of a former swamp. In the bed of the sloughs are occasional cypress trees, but not of a very old growth. On the north limit of the line, Giles' Bend, the banks cave or rather slide off from the top down to the water, moving outward at the same time, and the earth is washed away by the current. This movement is continually going on, the bank showing a regular succession of steps from the water edge to the top of the bank, 2 to 3 feet high, and 2 to 10 feet on top. Some of the more rapid slides bring to the light cypress stumps from 10 to 15 feet below the surface. These are now the only evidence of it having once been a cypress break, for all through the neck of land are growing cottonwood trees, some 4 feet in diameter, hackberry and ash of a very old growth; the soil on the surface nowhere showing the buckshot of the swamp, but has the ashen gray mellow soil always found in deposit of river silt remote from the point of overflowing banks. The rapidity of the caving in Giles' Bend may be computed from the observation on the line. On the 20th of August, I set a preliminary flag for a point of triangulation, and marked a tree due south from it, 625 feet, the flag being 10 feet from the edge of bank, and on the seventh of October the flag was gone, and the distance from the tree to the bank was 241 feet on the same line, showing that 394 feet of bank had gone in the river. I describe this point with minuteness of detail that you may more readily comprehend its importance in any improvement contemplated, for I think it the most important point in the survey, and the real point of danger to the harbor of Natchez. Should the river wear its way through this point, as it will at no distant time, its course will be to the east of the line toward the bluffs, and the rebound must cut away the Natchez Bar and the point of land on which Vidalia now stands. This will be followed by the inevitable sand-bar on the opposite shore, commencing near the light-post and extending to Rocky Point, below Natchez.

While describing the character of Giles' Bend and Swamp, I have said but little of points west of the line between the two points of starting and ending, the shore being a sand-bar called Dunham's Bar, from the north end of base-line to Cowpen Bend. At the south end of Giles' Swamp line the bar needs no special description, and the soil and bank from the lower point of bar for half a mile are nearly stationary, caving very little at the upper end, and increasing a little all the way down, then down to the light-post at the old corral the caving increases; average distance from the shore to the bluff is about 300 yards, at some points much less, at others more. The greatest amount of cave during the progress of this survey has been directly opposite Station 27, east line. From August 12 until October 10 it was 73 feet, sliding cave; at other points the caving is by crumbling from the top and washing at the water-line. At the light-post also the caves are crumbling, going on at a lessening rate until we come to the bark spur dike at the head of a ledge of soapstone-like formation above Brown's Saw-mill. This ledge is 7½ feet above the low-water line (1872) on the Natchez gauge, and leaving the bank at an angle of 7½° extends below the lower spur-dike (there are three of them), the whole length of ledge being 725 yards, with occasional breaks through it. From the upper spur-dike down to the rocky point below Natchez the foot of the bluffs forms the shore line; the bluffs being of a composition that will resist the wearing power of the water for many years. The rocky point, which has a very gradual slope far into the river, is composed of thin layers of conglomerate rock, gravel, and sand, with slight mixture of clay. This is as far down the river as it is useful to carry the survey on the Mississippi bank.

Commencing a description of the bank on the Louisiana shore at the foot of Rifle Point Bar, I will describe the dangerous points as they are reached.

At the point of starting, the foot of the bar is slowly extending down the river toward Good Hope Landing, with nearly stationary banks. The current leaving the Mississippi shore has crossed to the Louisiana shore, and runs with its greatest force at the head of the old bed of Lake Concordia, above Bullitt's Bayou. This old bed of the river and lake is covered with a growth of willow trees, some of them 2 feet in diameter; the soil of a loose ashy appearance 10 to 15 feet below the surface, then a blue clayey substance that dissolves rapidly where running water comes in contact with it, this stratum varying in depth from 5 to 12 feet; under this is a more tenacious formation, of nearly the same color, varying in thickness from 5 to 8 feet; then the treacherous composition of sand and whitish clay, forming quicksand. Caving

here is going on very rapidly at this time, and is only checked by the hard vegetable decomposition in the old bed of Bullitt's Bayou. This now forms a spur-dike, breaking the force of the current and forming a great eddy below it that is washing away the alluvial bank below it for 400 yards. There is some danger of the river making its way through to the lake again after an absence of some centuries, though I do not consider this a near termination. A greater probability is, that in the event of continued caving the river will pass through the low grounds near the old track of Bullitt's Bayou toward the Marengo Swamps, and enter the lake at the Waterloo and Marengo breaks, this course being much the shorter.

The banks from Bullitt's Bayou (station 61, west line) to the edge of the willow swamp—a part of what was called Grassy Lake—is continually crumbling off, down to Station 49, west line; below this, down to Station 32, the lower limit of the willow swamp, is a continuous sliding bank, setting gradually in regular steps; as it washes away from the water edge another break appears at the top of the bank. The soil here has much the appearance as at the head of Lake Concordia, except that the depth of the ashy-looking deposit above the original bed of Grassy Lake is greater, it varying from 10 to 20 feet below the surface; underlaying it are the same layers of clay, in greater or less stages of perfection; then the quicksand, with transpiration water oozing through from the lakes and water-holes. This swamp has its limits well defined by the timber growing on and around it. It is surrounded by the usual kinds of trees growing in the wooded lands here, say, cottonwood, ash, hackberry, and gum, with the cottonwood predominating, while in the lake bed are willows only, none of them more than 8 inches diameter. A profile of the surface, on a line having the direction of the point of swamp most distant from the river to a levee, will show the general surface level.

There is some danger of the river going through to the lake at this swamp. It is in the immediate track of the waterflow from several crevasses that have broken through the levees. Since 1860 the lands have been much washed out. A cross-section from Station 32 to Lake Concordia to a point 150 feet below the great Waterloo break—in the lake line of levels, north bank—will show the extent of damage by washing, and the facilities created for a rapid flow from the river to the lake, at this point alone, with a very strong probability that the Bayou Cocodrie would soon become enlarged to an extent that would keep the Black and Tensas rivers constantly in an overflowed condition during high-water in the Mississippi River.

From this point, Station 32, west line, to the light-post, Station 21, east line, near the foot of Lake Concordia, constant caving is going on; the same formations exist in the soil—the old sand-bar, upper stratum, buckshot; below it, sand; then the grayish blue, half-formed clay; then quicksand.

From Station 21, down to 37, Natchez sand-bar extends; below this, to Station 39, the bank is stationary. Station 40 is opposite Rocky Point, and on a stationary bank; thence, down to lower end of Arnolia Pasture, is a slightly-caving bank, and is the lower end of this survey.

From Station 44, near the Arnolia gin-house, I ran a line of levels for a cross-section of the country between the river here and Lake Concordia, and across the lake to the river again, crossing the river again to Dunham's Bar, then to the river again at the foot of Giles's Bend.

By looking at the large map accompanying this report, you can form a better idea of the many dry bayous and sloughs than you could possibly do from a minute description. There are many of them, and all running nearly in the same direction, that is, all bear to the east, in the direction followed by Lake Concordia. There is one exception to this, and it was made by cutting short canals from one slough to another for the purpose of draining into the lake through a culvert that was put under the levee at the Marengo break, and another one was put in at the Waterloo break, or rather where these breaks are now, the culverts being the direct cause of the levees breaking.

I suppose that no one disputes the evident conclusion that Lake Concordia was made a lake by a cut-off near the line of bluffs northeast of it, and that the cut-off must have been made by the river through a sand-bar of its own formation. I do not know of any tradition or history fixing the time when this occurred, but it must have been after the first settlement of Louisiana. Be this as it may, I have found tough blue or yellowish-gray clay anywhere on the Louisiana shore, except near the light-post at Station 21, east line. Here are the only evidences to be found that the river has occupied nearly the same place for fifty, perhaps hundreds of years. The same kind of clay mentioned is found on both shores; trees of not less than fifty years' growth are standing on opposite banks of the river less than 4,000 feet distant from each other. From these and other observations I conclude that the Mississippi River is repeating its movements of many years.

At my triangulation station, north 60° 30′ east from the north end of base-line, the largest trees do not exceed 16 inches diameter, and these are cottonwood, growing on what appears to be the natural boundary of the river, dividing itself from the later-formed sand-bar by a well-defined bank.

On the Louisiana side of the river, and but a short distance above Good Hope Landing, are cottonwood trees of a very old growth, one of which is a bearing tree of the land survey of United States in 1828, which was then described as a "cottonwood tree, ten in. dia." I mention these facts for the reason that they may be of use to you in determining the remedy to be applied to prevent a total destruction of the present harbor of Natchez, which a cut-off through Giles' and Cowpen bends would certainly effect.

The description of the shores of the Lake Concordia need not occupy much time, and will be confined, in general, to the character of the bank formations and the effect on the adjacent country, if it should become the water-way of the Mississippi River.

The south bank, which is the important one now, will not readily give way to the wearing power of the Mississippi. The composition is such that it will withstand its force for many years. The curves are regular and the slopes gradual, and coated with a composition of small gravel, some shells (muscle), and a hard clay and coarse sand.

On the south arm near bayou are a number of small bayous leading south and west, all of them with sandy banks and very friable.

Bayou Cocodrie is the same in character; a description of borings, made to reach the low-water levels of the Mississippi, will explain the material to that depth. Above the water-line in the lake the alluvial deposits scarcely vary any from that of the river. The greatest depth of water found in the lake was 40 feet. This, the deepest part of the lake, is near the foot of Vidal's Island. The water-level (surface) in the lake is 25.8 feet above the zero of the Natchez water-gauge, and lowest point at bottom of the lake is 14.2 feet below the zero point. The average channel depth from Giles' Bend down to Rocky Point is nearly 54 feet below the same point. This shows that since Lake Concordia ceased to be the water-way of the Mississippi River, its bed has been elevated from 40 to 80 feet, and all of this filling has been accomplished very slowly. The soundings in the lake all show a hard-clay bottom, the lead frequently bringing up small shells and occasionally fine gravel, which form an extremely firm bed that must extend down many feet from its present surface. The same character in the formations exists for several feet above the present water-line, gradually becoming mixed with the alluvial soil of the surface ground, losing much of its tenacity as it nears the top of the bank.

On the south arm of the lake, that is, that part south and west of Vidal's Island, from which is the only outlet, Bayou Cocodrie, having a high-water capacity of discharge through a section of nearly 1,200 feet, the banks are of a more friable nature, showing the banks to be easily moved, and the water-way frequently changing position. The evidence of this is seen in the small island, an occasional deep wash-out or hole in the course of the stream. In the vicinity of the bayou leading from the lake are numerous small bayous, or sloughs, all with friable banks, and having a direction running west of south. Bayou Cocodrie runs a very winding course, one fork terminating at Lake Cocodrie, 8 miles south, 10 miles west of the point of departure; another branch, or fork, entering Black River 17 miles south and 14 miles west of the departing point on the lake. It enters Black River about 7 miles north of the junction of Black and Red rivers. The section of country is interlaced with numerous small bayous and small lakes, and is fitly called the Black River Swamps. It will demand consideration while discussing the improvements for the harbors of Natchez and Vidalia.

After the foregoing descriptions of the banks and currents of the river and lake, a further description of land, especially that lying between the Mississippi River and Lake Concordia, will be in order, the general characteristics being sandy ridges divided by low sloughs, all terminating in low swamps, and all having a direction conforming with the north shore of the lake, and all nearing each other near the foot of the lake, where they now abruptly end at the river bank. It will be seen by the profiles crossing this strip of land at different places that the general level of the ridges are above that of the river bank, and that the great swamps that existed twenty years since are now nearly gone and the river bank now occupies their most southern and western limit; all that remains of them are, that described as the Willow Swamp and a part of the Waterloo and Marengo swamps.

The Willow Swamp is what remains of Grassy Lake, a lake nearly 3 miles long and a half mile wide. A number of small bayous drained into it, Bullitt's Bayou being one, entering at its western extremity and leaving it again through the south bank 2 miles from its entrance.

A large part of the Marengo Swamp still remains between Stations 5 and 15 of west line, with a general depression of 3¼ feet lower than the lake bank. The frequent crevasses of the past twenty years have filled it to a great extent.

The narrowest point between the river and lake banks is now immediately along my base-line, and is 952 feet from bank to bank.

The neck of land through from Giles' Bend to Cowpen Bend has before been described; some features, however, were not mentioned.

The slough called Long Lake is crossed by my base-line and by the line running from Cowpen Bend to Giles' Bend, and is peculiar in some of its features. It has its head near the upper end of Dunham's Bar and follows down the bar and on the bar, following a mile and a half, when it passes on to the older bottom-lands, and its lower terminus being nearly opposite Station 28, east line, at the river bank. It seems to have formed a connection with an older slough that drained a portion of Giles' Swamp in the older bottom, and the newer formation of the bar closed up its lower end; it followed the course of this through the bottom to the river, about 1¼ miles below, near the bluffs. It carries water during the low stages of the river westward into the sand-bar, while the old bayou takes another part of it east to the river near the bluffs.

After a review of the operations in the field during the survey, it seems that the remedy to be applied for the protection of the Natchez and Vidalia harbors must be—

First. To prevent the Mississippi River from cutting through the neck of land called Giles' Swamp, from Giles' Bend to Cowpen Bend.

Second. To prevent it from entering Lake Concordia.

If it should go through Giles' Swamp, the effect will only be felt on the Natchez harbor and the point of land on which Vidalia is situated. If it goes into Lake Concordia the condition of the levees on the south bank of it will not confine it to the lake, but the whole country south of it will be inundated from the flow through Cocodrie and other bayous in that vicinity. The Vidalia point will wear away; the result must be similar to that at Vicksburg.

A remedy for both of these contingencies can be applied in the construction of spur-dikes, four in Giles' Bend and six in the Marengo Bend; those on the Mississippi shore to be about 1,250 feet apart—the first to be placed at the upper end of the bend where the river runs near the bluffs, and should not extend beyond the outer eddy-line; the others to be located according to the circumstances disclosed by the first.

Those on the Louisiana shore should commence with a first a little above the foot of the sand-bar (Rifle Point Bar), and the second above the old bed of the river—Lake Concordia; and a third at the mouth of Bullitt's Bayou. None of them should project into the river outside of the eddy-line, but should be so located as to divide the eddies, and thus force a change of position. The other spur-dikes on this side of the river should be located after the first three are constructed and their effect on the current disclosed.

The result of placing these dikes will be to direct the current against Dunham's Bar, where the channel would soon follow.

Very respectfully,

W. C. MELVIN,
Assistant Engineer.

Maj. W. H. H. BENYAURD,
Corps of Engineers, U. S. A.

APPENDIX P.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—ICE-HARBOR AT SAINT LOUIS, MISSOURI—IMPROVING MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU AND MINTON'S POINT, MISSOURI—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

REPORT OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., July 28, 1880.

GENERAL: I have the honor to herewith transmit my annual reports for the year ending June 30, 1880.

I assumed charge of the works on the 30th of March, relieving Col. James H. Simpson, Corps of Engineers. I had previously been connected with them, under Colonel Simpson's orders, from the beginning of the year.

My reports cover the operations of the entire year.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

No work was done within these limits during the year other than surveys and the establishment of gauges. The appropriations, of $20,000 of June 18, 1878, and of $15,000 of March 3, 1879, are still available, with the exception of $1,174.15, the amount expended for the purposes above mentioned over and above a previous balance.

This money, having been appropriated for the improvement of the Mississippi between the Illinois and Ohio rivers, must, I think, be applied so as to benefit the greatest number of persons interested in the navigation of the entire stretch of river lying between those limits. There is no doubt that one important feature of an improved river is convenient access to landings; but the *most* important result to be attained by the improvement, and the one first to be aimed at, is cheap

through transportation for freight. Passenger traffic is secondary, and so is the freight for any single point. The estimate of the cost of the improvement is for procuring this cheap through transportation, and does not include the cost of improving harbors in cases where special works are required for that purpose.

The harbor of Alton, which is the most important landing in that section of the Mississippi, is in need of improvement; but there is no difficulty with the navigation in that vicinity for vessels that do not stop there, and unless Congress should expressly appropriate funds for that work it should be deferred, I think, until the river has reached such a stage of improvement that attention can be turned from the primary object of securing good *through* navigation, to the secondary one of providing convenient access to landings. Additional estimates can then be submitted to cover the cases of such landings as remain inconvenient after the general improvement has been completed.

Considerable difficulty is found near the head of Piasa Island. The channel is exceedingly tortuous, and near the island is a ledge of rock which is dangerous at low-water. On the 23d of April I recommended that the available funds be applied to the improvement of that locality, and requested authority to make a hydrographic survey, with a view to preparing a plan of the works required and an estimate of their cost. This recommendation was approved so far as to authorize the survey, and the latter was begun in May. The field work was completed in June, and the map is now being prepared. A plan will be submitted for your consideration at an early day.

The dam at Ellis Island remains as reported last year by my predecessor.

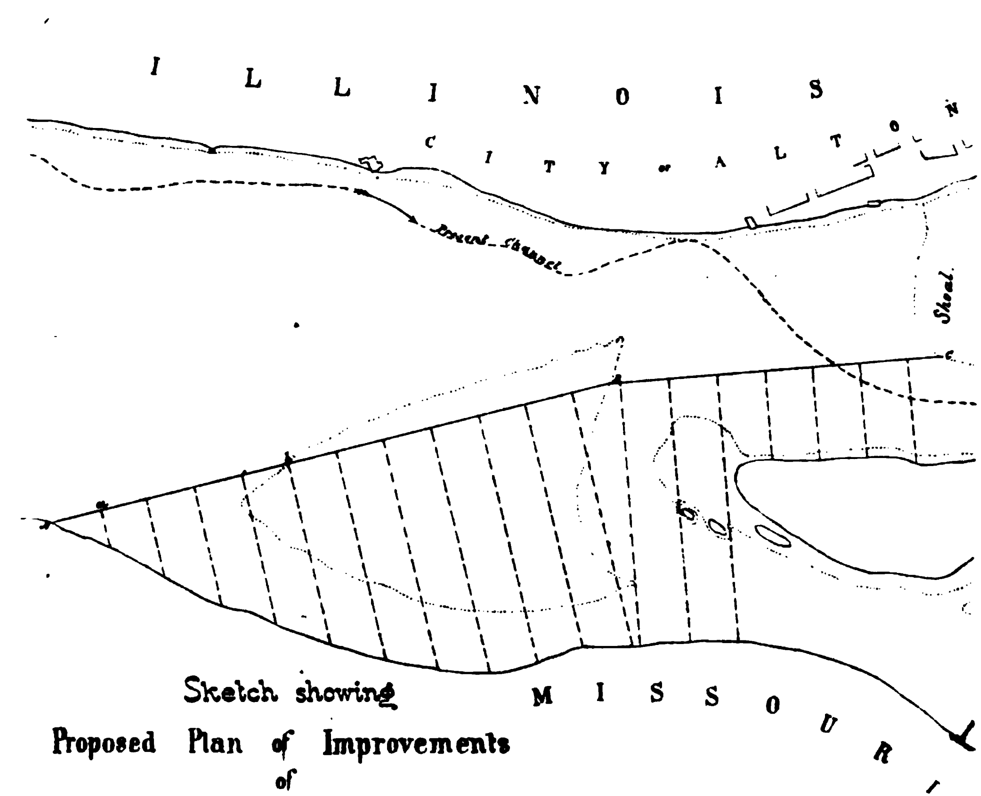
The sum of $1,500 was allotted for the purpose of making the survey near Piasa Island, to which $200 was afterwards added for the purpose of closing a gap between Eagle Nest and Hop Hollow, which existed in the permanent triangulation of the district. The completion of that work will give a connected triangulation from the mouth of the Illinois to the mouth of the Ohio.

The expenditures were:

For hydrographic survey	$1,507 85
For water gauges	192 15
Total	1,700 00

The river and harbor act of June 14, 1880, contains in the item appropriating $250,000 for the improvement of the Mississippi River between the Illinois and Ohio rivers, the following proviso, viz, "of which sum * * * $15,000 *may* be expended on the harbor at Alton," the italics being mine. The authority here given implies a desire that the sum mentioned shall be expended at Alton, and this desire should be complied with unless there are good reasons to the contrary. Strong reasons, based upon general principles, have already been given. There are others appertaining to the particular circumstances of this case which have their weight. The estimated cost of the works required for the improvement of Alton Harbor is $71,000 (see report of Col. James H. Simpson, Corps of Engineers, dated February 9, 1880), and that portion of the works which should be built the first year is estimated to cost $39,000. An examination of the plan of improvement shows that an expenditure much less than $39,000 will have little or no beneficial effect.

The works proposed include a dike, A, B, C (see adjoining sketch), connected by hurdles at intervals of about 400 feet, with the Missouri



Sketch showing
Proposed Plan of Improvements
of
ALTON HARBOR, ILL.

shore. Their object is to collect all the waste water of the river at stages below 14 feet and throw it against the main channel as it comes down the Illinois shore, thus diverting that channel and causing it to attack the shoal in front of the Alton Landing. The $15,000 under discussion could only be applied to beginning the dike near the point A. The money would be sufficient to cross the deep water near *a* and to carry the dike as far as somewhere near *b*. The work stopping here could not be expected to exert any beneficial effect upon the harbor. It would exert an injurious effect, however, upon its own future. The foundation near *b* is now a bar, which is dry at low-water. The estimate is based upon utilizing this bar with a view to cheap and rapid construction. If the dike stops here for a season the bar will be scoured out, and it will be necessary to increase the estimate. Without the dike the bar may be expected to remain substantially in the same position for a considerable period. The only alternative is to make a further allotment of $24,000 from the general appropriation, so that the work can be pushed through as far as the point B in one season. That cannot properly be done for the reason that the general fund is at best not large enough to answer the demands of the general navigation interests, and the diversion of any portion of it at this time to the work referred to must be indirectly an injury to commerce.

SAWYER BEND.

The revetment here remains in good condition. No work was done during the year and none is contemplated for next year, unless some repairs should become necessary.

VENICE DIKE.

No work done and none contemplated.

CAHOKIA CHUTE.

The June rise of last year having filled up to a considerable degree the shallow channel at the upper part of the west chute, a heavy strain was brought to bear upon the dam across Cahokia Chute by the falling river, the result of which was, in the latter part of August, a breach in the dam. It being necessary to close this breach to prevent the destruction of the dam, and the special appropriation being exhausted, an allotment was made for the purpose from the general fund.

The breach was repaired in September, and the dam was afterwards strengthened at points which seemed to require it, and it has since remained in good condition.

Details of the work will be found in the report of Assistant Engineer D. M. Currie, hereto appended and marked A. Extensive shoaling has taken place above it, and it is thought that the severe strains will not be renewed.

The expenditures were:

9,556.77 cubic yards riprap	$12,280 65	
118.09 cords brush	246 81	
		$12,527 46
Engineering and contingencies		411 25
		12,938 71

HORSETAIL BAR.

The term Horsetail Bar includes a stretch of river about 5 miles long extending from the river Des Peres, the southern boundary of Saint Louis, to the foot of Carroll's Island. The average width when the works were begun was about 5,000 feet. There were several large movable bars which obstructed the navigation, and it was no uncommon thing to find as little as 4 feet depth of water in the channel during the low stages of the autumn, the obstacle being sometimes at one point and sometimes at another. The bottom being composed of shifting sands and mud, this shallow water was evidently the result of the inordinate width, and the obvious means of increasing the depth was to reduce the width. It was decided to undertake the contraction of the river to a width of 2,500 feet. For this purpose a series of jetties or dikes perpendicular to the shore were planned, and their construction begun in 1873. Their outer extremities were to be connected by longitudinal dikes or training-walls located upon the lines of the new banks. The construction of one of these training-walls was begun in 1877. The object of these works was to confine the water of the river within the prescribed limits by means of their own solidity and weight. They were built of riprap upon a foundation of brush. The great volume and velocity of th Mississippi, combined with the treacherous nature of the soil upon which these structures rested, rendered the jetties a comparatively easy prey to the currents. The attacks upon them were facilitated by their great length and by the considerable intervals which separated them from each other, neither of which could well be reduced in a river of such magnitude. The training-wall, receiving the shock of the stream in a more favorable direction, was not so liable to destruction by the current; but a breach 800 feet long, occasioned by an ice-gorge, in the winter of 1878–'79, showed that this part of the work had in the climate an enemy which was quite as redoubtable. It was then concluded that to resist all the destructive forces at work nothing less than a solid mass of earth between the new and old banks would answer, or, in other words, that the land must be wholly reclaimed, and that works in the stream relying wholly upon themselves were not sufficient. In the spring of 1879 the upper part of the area included between the training-wall and the Illinois shore was divided up by hurdles similar to those used on the Garonne and described in the last annual report. Their object was to cause the water to deposit its sediment behind the training-wall as it progressed. The solid form of the latter was preserved, but a cheaper method of construction was introduced, employing temporary instead of permanent materials. The stone jetties were in a dilapidated condition and were abandoned.

The remarkable results obtained from the use of the hurdles last year led to the application this year of that class of construction to all parts of the work. At many places, particularly in the line of the training-wall, the water was too deep for the advantageous use of piles. At such points the hurdles, or equivalent brush obstacles, instead of being made continuous and in position, were constructed either continuous or in sections upon floating ways from which they were launched. One side was secured to the bottom by anchors, while the other side was held up at the surface of the water by buoys. Various forms of brush obstacles were used. They are shown in figures 2 to 8, and are fully described in the report of Assistant Engineer D. M. Currie, by whom most of them were designed. His report is appended, marked A, and is intended to form part of this report. At first these floating obstacles

were anchored to a horizontal mattress or sill (see figures 2 to 7), the latter being intended to prevent the scour that was to be feared from placing them in contact with swiftly running water. Increasing confidence in their efficiency led to the temporary abandonment of the horizontal member for economical reasons. Further experience is necessary to determine whether it will be advantageous to resume that method of construction.

The governing principle is the same in all of these forms of construction. This is to utilize the building power of the river by inclosing the ground to be reclaimed within slight permeable obstacles. These, while smoothing out the boils and whirls and checking the velocity of the water sufficiently to cause it to drop a part of its load, present no great obstacle to its flow. They are dike-builders rather than dikes themselves. Allowing the water to circulate freely they constantly introduce new supplies of fully loaded fluid, and thus gradually and easily build up the new banks. Under this system the progress has been rapid, economical, and thus far satisfactory in its results.

A map showing the plan of the works and their present state of completion is herewith transmitted.

Soundings taken in March, 1880, are written upright so as to read with the title. Those taken upon each day are inclosed in brackets opposite which the date is written. The stage of the river for that day is found in the gauge record at the margin of the sheet. Soundings taken on the 29th and 30th of June, 1880, are written at right angles so as to read when the map is revolved 90° to the right. These soundings are reduced to the same stage as those of March. Those having the minus sign indicate that the ground would be uncovered with the river at that stage. The heavy, broken, and dotted lines show the plan of the works not yet begun; the full lines those now completed. Upon each line of hurdles are given the dates when it was built and when it was repaired.

It is no easy matter in the case of a silt-bearing stream to show definitely upon paper the effect of the works of improvement upon the channel. A statement that a certain depth existed before the execution of the works and another depth existed afterwards might be strictly true, but at the same time might be misleading and unfair. The channel is constantly shifting its position and the bottom fills or scours with the rise or fall of the water surface. It is a common occurrence after the summer rise that a gradual fall of 15 inches on the gauge is attended by an increase of 9 inches in the depth; that is, that during this fall of 15 inches there is a scour of 2 feet. Comparative sections of the channel are therefore useless for indicating the effects of the works. Knowing that with banks not too far apart there will always be somewhere between them a good channel at all stages, we must turn for definite information to the process of building up the new banks.

Several sections embodying information obtained at dates earlier than those of the written soundings are given upon the map showing the results of the operations thus far. These may be supplemented by the statement that the least depth of water found in the channel at any time during the year was 8 feet. In examining these sections it is to be borne in mind that the works are built to a height of about 15 feet above low-water, and that that portion of the river bed lying below that level is mainly to be considered when making inquiry as to their effect.

Section on E F shows a maximum fill of 27 feet since March, 1880, over a width of about 320 feet and an average fill of about 10 feet.

Section G H shows a maximum fill of 64 feet since the spring of 1879, and an average of about 10 feet since March, 1880.

Section I K shows a maximum of 20 feet since April, 1879, and an average of about 6 feet since January, 1880.

Section L M shows a maximum of 48 feet since April, 1879, and an average of about 3 feet since January, 1880.

Section N O shows a portion of ground which was reclaimed to a height of about 15 feet above low-water last year. Young willows began at once to grow upon it, and deposits have now been secured to a maximum height of 19 feet 6 inches above low-water. These deposits have been obtained under unfavorable circumstances. Most of the building material comes from the Missouri River.

If the Upper Mississippi is relatively high, the water of the Missouri is kept on the west side of the river and away from the works. That has been the case during the larger portion of the last spring. The works have cost more and the results, large as they are, have been less than may reasonably be expected under ordinary circumstances.

The shoaling action is still going on, and during the present high water may be expected to progress more rapidly than ever, as it is at such times that the great movements of silt take place.

These results are satisfactory. Nevertheless it is well to be cautious about accepting them as final They are still to be secured and rendered permanent. A great flood choking up the present low-water channel of the river might throw it over into our new made land and undo a large part of this work.

Fortunately these obstacles are as cheap as they are frail, and can be often renewed without excessive cost. When the land behind them has once become consolidated they may be expected, with some additions, to secure it from future attack. The improvement cannot be regarded as secure until the land has been raised to a height of at least 25 feet above low-water. The hurdles are built to a height of about 15 feet above low-water, and are expected to cause deposits to that level. They cannot be advantageously built much higher, because they would be exposed to rapid decay, while their action would be limited to the short periods of high-water. It is proposed to secure the additional height of deposit by a growth of willows covering the entire area to be reclaimed. These with their roots will consolidate the land already formed and with their branches will cause further deposits at high-water. The number of years which will be required to raise the land to a secure height is altogether uncertain, depending upon the height and duration of the spring freshets, and also upon the relative height of the Upper Mississippi and the Missouri rivers during those freshets. It is necessary that the government should control the land and the willow growth; and this raises a question of riparian rights which will be again alluded to further on.

The willow springs up spontaneously upon the newly formed alluvial lands in the Mississippi; but observation is wanting to show what is the lowest level at which it will grow, and how much time can be gained by planting cuttings. To gain some information upon the subject, as well as to ascertain the best season for planting, I have had a few cuttings planted at different levels about the first of each month during the present season, using pieces of willow from ½ inch to 4 inches in diameter. All the cuttings planted in March lived. Many of those planted in April and all those planted in May and June died. It is proposed to continue these experiments throughout the working season.

The greatest size that can be given to the enclosed areas is not as yet fully determined. The size of those constructed this spring has been

about 1,400 by 400 feet, the shorter dimension being measured parallel to the bank. It is thought that this dimension can be increased. The other dimension being measured perpendicular to the bank depends upon the amount that the river width is to be contracted, and may be made the full length from the old to the new bank.

The total cost of the fixed hurdles in the transverse lines, including engineering and contingencies and all repairs, was $1.43 per running foot. Of this, 44 cents, or 31 per cent., was the cost of transportation and wear and tear of the equipment. The cost of the curtains or floating obstacles was $1 87 per running foot; but with these, owing to the adverse circumstance before referred to, of a relatively low Missouri River, it was necessary to go over the same ground many times. To construct and repair 2,500 feet of dike consumed 21,000 feet of curtains, the total cost of which was $39,382.42, or $15.75 per running foot of dike. This, while not more than one-third what a stone dike would cost in the same depth of water, is hardly a fair showing of the economy of this system. At any point far enough below the mouth of the Missouri for the waters of the two rivers to have become thoroughly blended, or at Horsetail itself, under circumstances which are common, if not usual, there in the spring, the same results might have been obtained at a cost 50 per cent. less. Of the $15.75 above given, $4.08, or 26 per cent., was for transportation of material and the wear and tear of equipment.

The items of transportation, &c., have been separated in the statement of cost with a view to showing some of the pecuniary advantages which would result from increased annual appropriations and enlarged operations. Works were carried on last year at Cairo and Cahokia Chute, points separated by a distance of 180 miles. It being impracticable for one boat to do the towing for works so far apart, two boats were employed. Either of them could have done twice to three times the work it actually did do; yet neither could be dispensed with. The barges were more fully employed, but for similar reasons were not worked up to their full capacity. With the equipment fully employed, the cost of transportation might be reduced at least one-fourth. As it forms about 28 per cent. of the cost of the works at Horsetail, this would be equivalent to reducing the cost of those works 7 per cent.

The expenditures were—

Training-wall (2,500 feet):		
2,301.56 cubic yards riprap	$2,871 77	
3,759.85 cords brush	6,699 82	
23 piles	101 43	
Labor, rope, wire, equipment, &c	27,489 40	
		$37,162 42
Hurdles (32,000 feet):		
2,835 feet piles	13,519 00	
15,140 feet piles	3,276 00	
4,697.37 cords brush	8,671 89	
100 cubic yards riprap	129 00	
Labor, rope, wire, equipment, &c	17,661 65	
		43,257 54
Engineering and contingencies		4,723 43
Total		85,143 39

The works at Horsetail have been under the immediate supervision of Assistant Engineer D. M. Currie, to whose report reference has already been made. He is entitled to credit for intelligent study and zealous devotion to his work.

I have obtained useful hints as to some of the details of the structures, particularly the anchors, from Maj. Chas. R. Suter, and his assistant,

Capt. T. H. Handbury, Corps of Engineers, who have been working on a similar field in the Missouri River.

An allotment of $150,000 has been made to this work from the appropriation of June 14, 1880. It will be employed in the construction of brush obstacles similar to those used this spring, covering all the remaining ground to be reclaimed, in accordance with the plan herewith transmitted. It is expected that this will practically finish the work, though, as above explained, it must be the object of care for an uncertain number of years.

FORT CHARTRES DAM.

No work done and none contemplated.

TURKEY ISLAND DAM.

No work done and none contemplated.

PROTECTION OF BANK NEAR KASKASKIA.

This work was extended down stream a distance of 1,100 feet in July, when the funds allotted having been exhausted, it was suspended. It was discovered, however, in August, that owing to a considerable scour in front there were a number of slides, and that there was danger of great damage being done unless steps were taken at once to check the scour.

Accordingly $15,000 from the general appropriation were allotted in addition to the sums mentioned in Colonel Simpson's last annual report. This was employed in placing brush mattresses 50 feet wide along the foot of the slope, outside the former work, for a length of 3,305 feet. The danger of immediate destruction was thus removed, but the work is still in a precarious condition. For details, see the report of Assistant Engineer Charles S. True, which is hereto appended and marked B.

The expenditures were:

7,870.50 cubic yards riprap	$11,406 44	
2,100.20 cords brush	3,262 50	
Excavation	153 30	
Labor, rope, &c.	2,599 47	
		$17,421 71
Engineering and contingencies		1,279 71
		18,701 42

The direct protection of this bank is a difficult undertaking. The plan of construction has been that successfully employed at other points, viz, a brush mattress at the foot of the slope extending up to low-water mark, and above that level a covering of stone. This plan has not been here altogether successful.

A light covering of stone is not sufficient, and the soil is not stable enough to bear the weight of a heavy one. A continuous thatching of brush might answer the purpose temporarily, but it would soon decay. The act of June 14, 1880, contains a proviso allotting the sum of $20,000 to this work, which it is proposed to employ in an attempt to change the direction of attack of the river, and to finally cause deposits where there is now a scour. Beginning at the extreme upper end of the bend, permeable dikes of hurdle work will be run out at intervals into the stream.

The cost of the work seems to have far exceeded the expectations of Congress, by whose order it is being prosecuted. The appropriations for 1877, '78, and '79 were, respectively, $5,000, $10,000, and $8,000. The

expenditures were $5,000 (which was a total loss), $20,000, and $30,000, the differences being taken from the fund provided for the improvement of the navigation between the Illinois and Ohio Rivers. The original sums allotted by Congress being also taken from that fund, it would seem to be carrying out the will of Congress to add to them if the circumstances of the case require it. But the fact ought to be stated that this work is not now in the interest of the general navigation, but is mainly of importance as a protection of lands. Bank protection is a useful aid to navigation by stopping the supply of channel-choking material and by preventing the river from increasing its width; but the river in this vicinity is in a bad shape for perpetuation, and the advantage to be derived from protecting the bank is more than counterbalanced by the ugly shape of the channel and by the absorption of the funds so much needed elsewhere. It is much to be desired that any sums which are to be expended upon this work should be provided in addition to those designed for improving the navigation.

The cost of continuing the protection to the end of the bend is estimated at $204,000, of which $50,000 can be expended to advantage next year, if specially and independently provided.

LIBERTY ISLAND PROTECTION.

No work done and none contemplated unless some repairs should become necessary to the old work, which is now in good condition.

DEVIL'S ISLAND.

No work done and none contemplated.

DICKEY ISLAND TO MOUTH OF THE OHIO.

Operations were suspended about the middle of October, the appropriation being exhausted. The revetment was extended up stream a distance of 2,900 feet. It has been raised to a height of about 20 feet above low-water throughout its extent. The report of Assistant Engineer Chas. S. True, who had charge of the work, is appended, marked B, to which attention is invited for details.

One remarkable fact incidentally noted by Mr. True is the low-water width of the Mississippi River. A section was taken by him on the 25th of September, when the Gray's Point gauge read 7.07 feet above low-water, and it was found that the whole volume of the river was passing through a space 743 feet wide.

A still less width was noticed lower down but was not measured. In each case the channel was bounded on one side by an ordinary sand bar. This shows that no practicable amount of contraction of the river will insure deep water all the way across, and is to be borne in mind when projects are under consideration for improvement of Saint Louis Harbor or other important harbors.

The expenditures were:

13,648.90 cubic yards riprap	$21,616 12	
1,621.30 cords brush	4,872 79	
Excavation	100 35	
Labor, rope, &c	345 91	
		$26,935 17
Engineering and contingencies		1,271 78
		$28,206 95

The revetment at this locality now covers a length of 14,200 feet, including that portion previously covered by the spur-dikes of the Cairo Land Company. The latter was repaired and strengthened by the United States. The work wholly new covers a distance of 10,700 feet built in 1876, '77, '78, and '79. It consists of a brush mattress covering the foot of the slope, and a covering of stone above low-water mark, the latter extending to a height of about 20 feet above low-water. It is proposed to protect the bank above that level to a height of about 30 feet above low-water by a plantation of willows. For this purpose $5,000 have been allotted from the appropriation of June 14, 1880.

When that is done the original project will be completed and the work will have reached a stage when it becomes of secondary importance in the general scheme of improving the navigation. The local interest desires its extension, and this, while not of primary importance, will be useful to the navigation interests. It would be injurious to the latter, however, if it be allowed to absorb the funds needed so much more at other points.

It is recommended, therefore, that this work be separately provided for. The sum of $50,000 can be expended to advantage during the year ending June 30, 1882, if specially and independently provided. It is proposed to employ it in removing portions of two of the old spur-dikes, and in extending the protection about 1,500 feet down stream.

SURVEYS.

To comply with the provisions of the river and harbor act of March 3, 1879, a special survey was made of Alton Harbor and of the Mississippi River opposite to the mouth of the Missouri, for which the sum of $2,000 was allotted and expended from the appropriation for examinations and surveys and contingencies of rivers and harbors. Two differet subjects of discussion being involved, the map was divided, and that part covering Alton Harbor was forwarded with Colonel Simpson's report of February 9, 1880, and the remainder with his report of March 25.

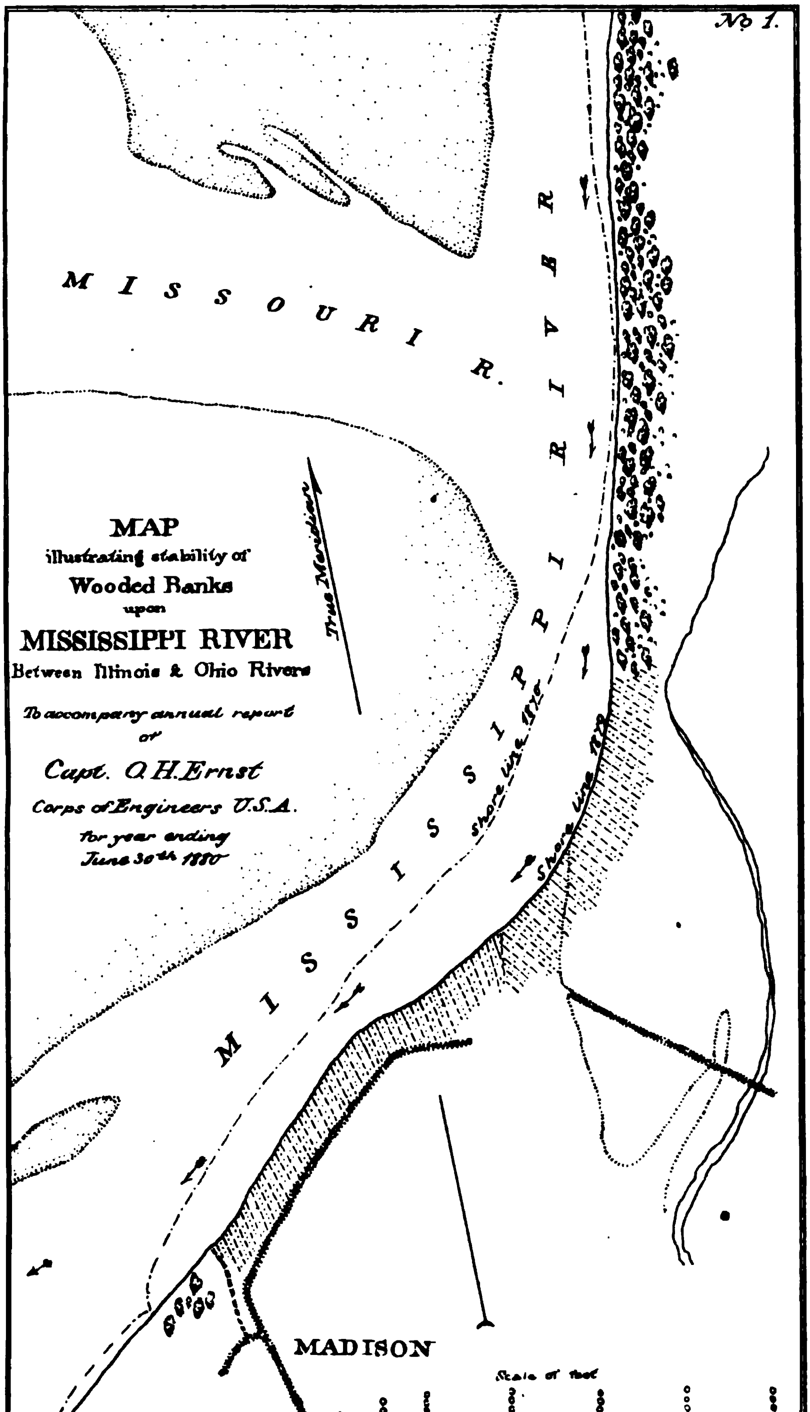
Much office labor was expended in working up the data obtained the previous year for the Board of Engineers upon the low-water navigation of the Mississippi and Missouri rivers, with a view to putting the information obtained in proper shape for transmittal to the Mississippi River Commission.

This work was under the immediate direction of Assistant Engineer R. E. McMath, who was assisted by Assistant Engineers Wm. Popp and W. S. Mitchell. His report, with 21 tables and 49 sheets of diagrams, was forwarded to Col. Z. B. Tower, Corps of Engineers, on the 7th of February, in compliance with your instructions of January 20, 1880.

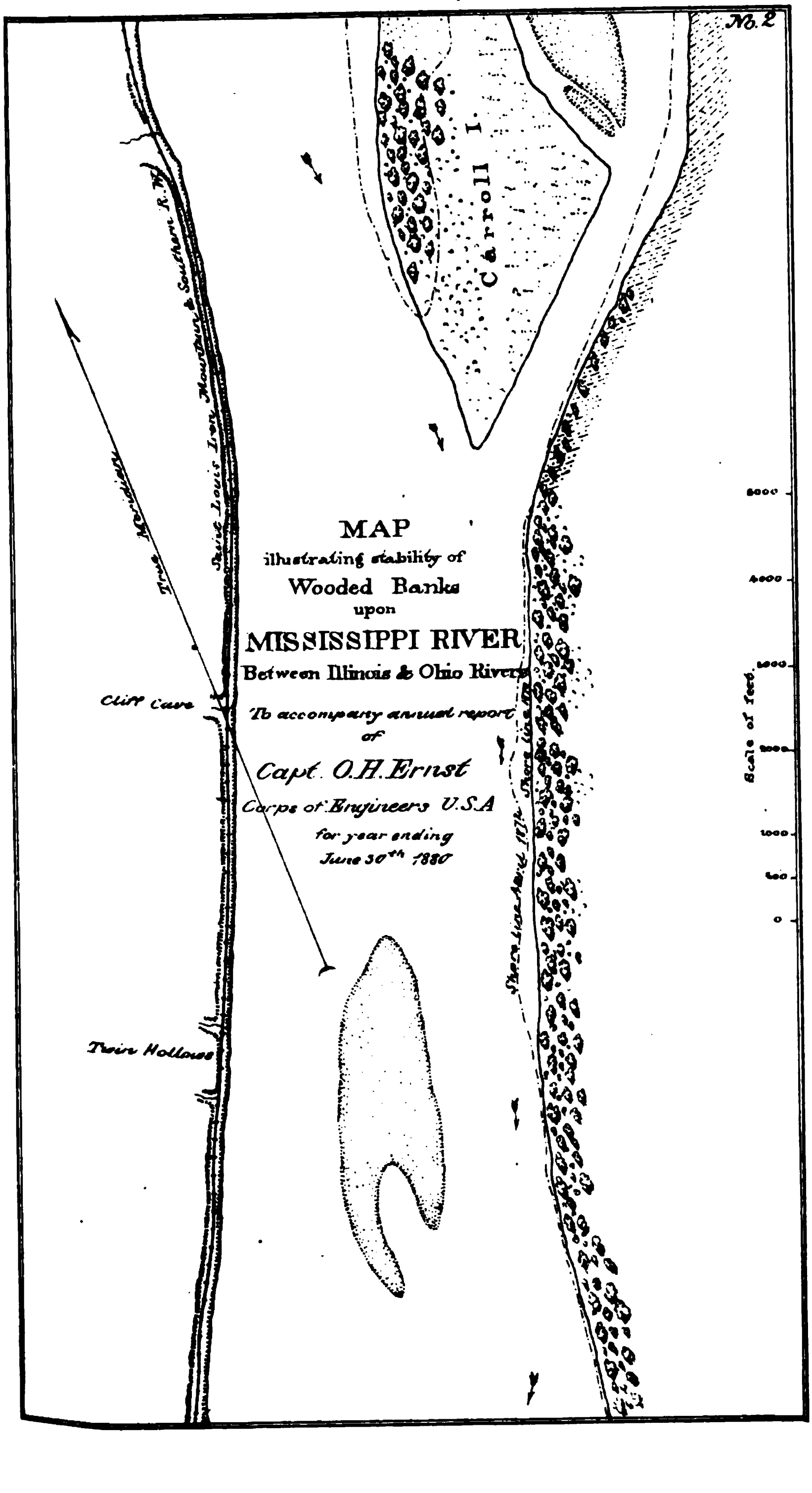
Included in the surveys undertaken for the Board, which were suspended upon the organization of the Mississippi River Commission, was a line of levels to extend from the mouth of the Illinois to the mouth of the Ohio.

The establishment of permanent bench-marks along the bank being necessary in carrying on the duties of this office, a party was organized to continue that work. Advantage was taken of the opportunity to retrace the shore lines, and correct the topography of our maps. This work has been carried down as far as Kaskaskia Bend, where it was suspended on account of the appropriation being exhausted. It was conducted by Assistant Engineer P. C. F. West, who is entitled to credit or skillful management.

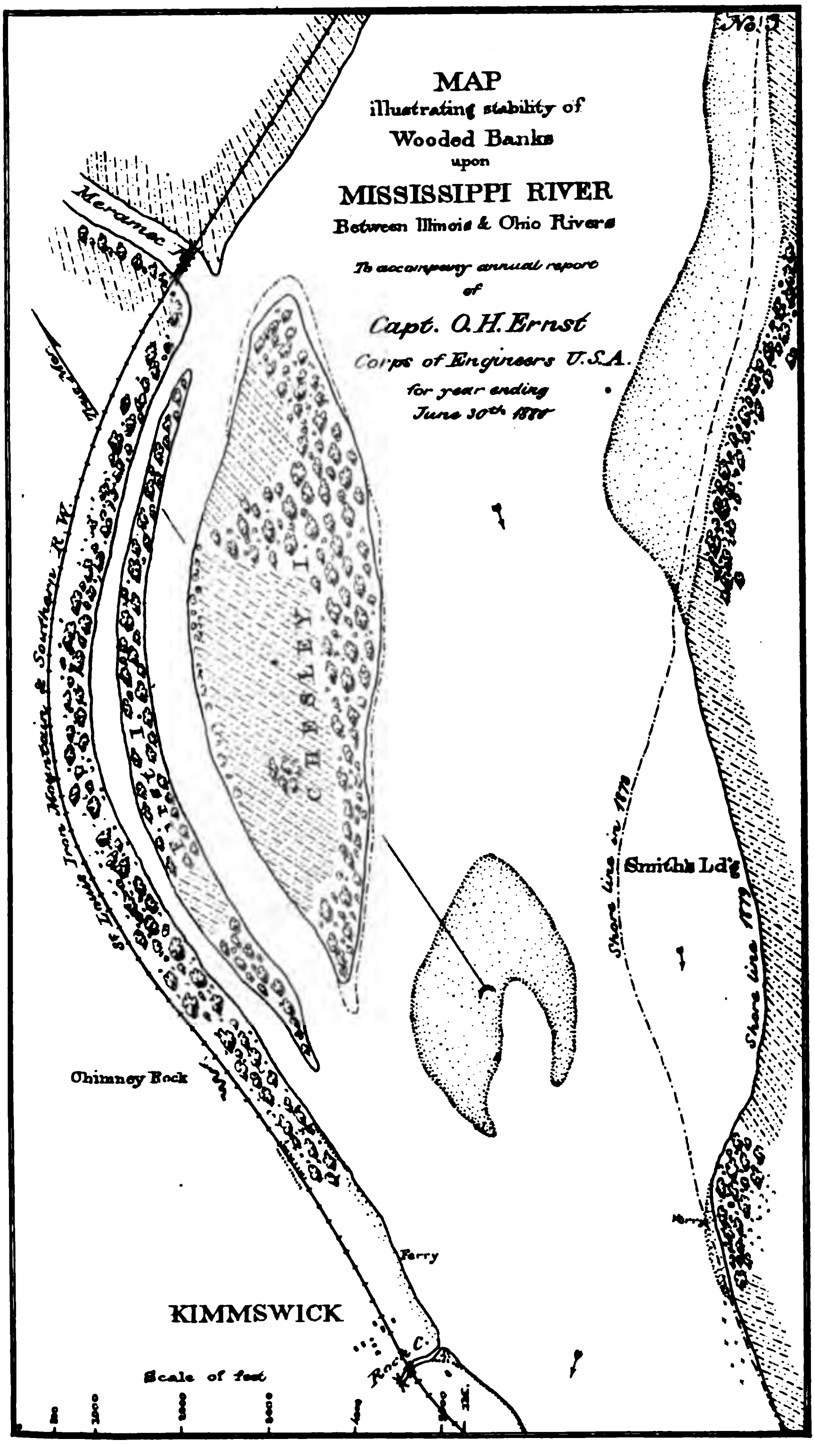
A resurvey was made of the protected bank near Cairo.

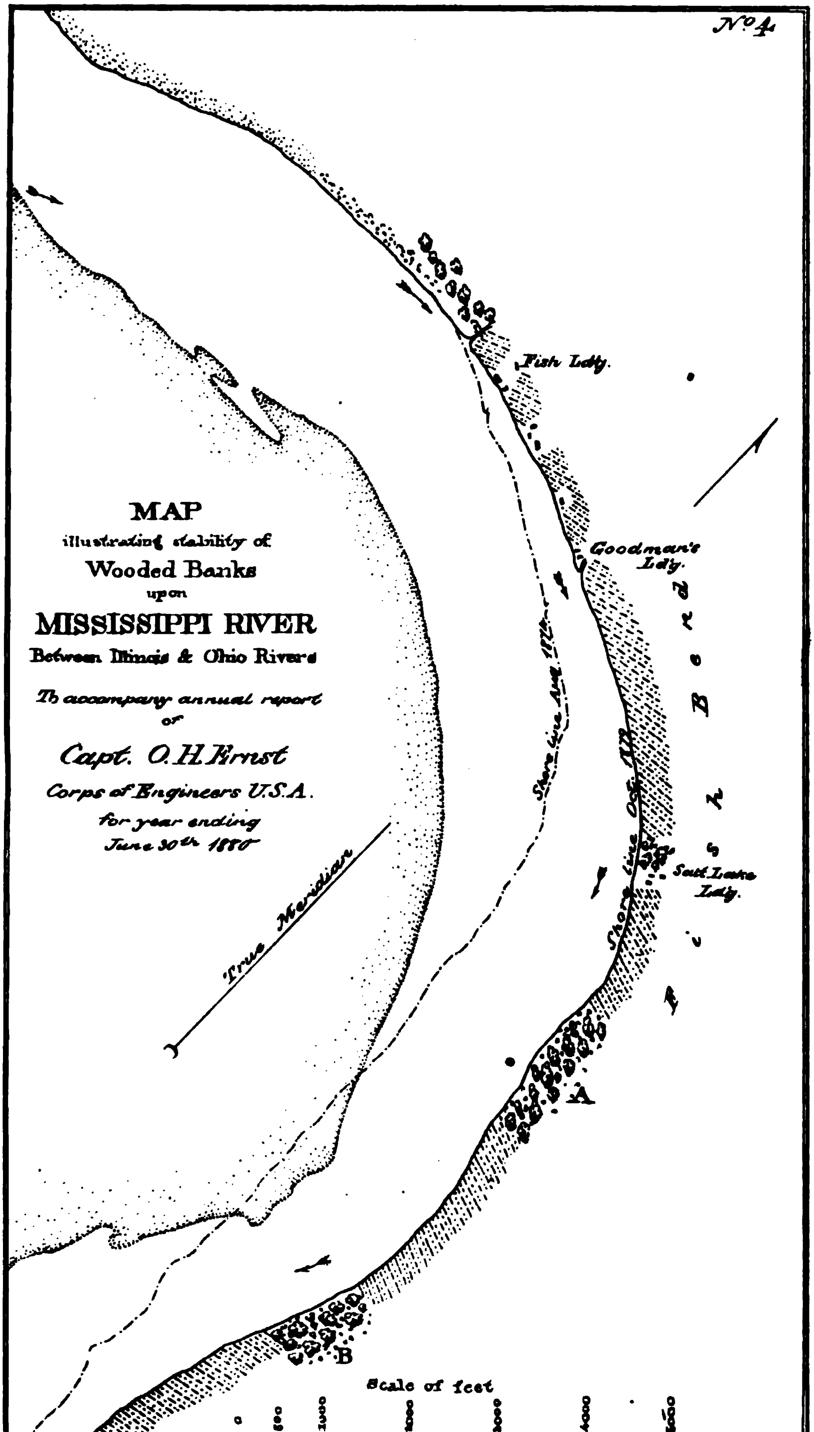


No 1.
MISSOURI R.
MISSISSIPPI RIVER
True Meridian
MAP
illustrating stability of
Wooded Banks
upon
MISSISSIPPI RIVER
Between Illinois & Ohio Rivers
To accompany annual report
of
Capt. O.H.Ernst
Corps of Engineers U.S.A.
for year ending
June 30th 1880
Shore line 1878
Shore line 1879
MADISON
Scale of feet
0
500
1000
2000
3000
4000
5000



No. 2
Carroll I.
MAP
illustrating stability of
Wooded Banks
upon
MISSISSIPPI RIVER
Between Illinois & Ohio Rivers
To accompany annual report
of
Capt. O.H. Ernst
Corps of Engineers U.S.A
for year ending
June 30th 1880
True Meridian
Saint Louis Iron Mountain & Southern R.W.
Cliff Cave
Twin Hollows
Shore Line April 1874
Shore line 1879
Scale of feet
5000
4000
3000
2000
1000
500
0


No. 3
MAP
illustrating stability of
Wooded Banks
upon
MISSISSIPPI RIVER
Between Illinois & Ohio Rivers
To accompany annual report
of
Capt. O.H. Ernst
Corps of Engineers U.S.A.
for year ending
June 30th 1880
Meramec R.
CHESLEY I.
St Louis Iron Mountain & Southern R.W.
Smith's Ld'g
Chimney Rock
Ferry
KIMMSWICK
Rock C.
Scale of feet


No. 4
MAP
illustrating stability of
Wooded Banks
upon
MISSISSIPPI RIVER
Between Illinois & Ohio Rivers
To accompany annual report
of
Capt. O. H. Ernst
Corps of Engineers U.S.A.
for year ending
June 30th 1880
True Meridian
Fish Ldg.
Goodman's Ldg.
Salt Lake Ldg.
Shore line Aug. 1878
Shore line Oct. 1879
A
B
Scale of feet
0
500
1000
2000
3000
4000
5000

The gauge at Gray's Point has been read daily throughout the year. Gauges were established in April at Grafton and Alton, and daily observations have since been recorded.

The expenditures were:

Survey at Alton Harbor, &c	$2,000 00
Examinations, &c., required by Board of Engineers on low-water navigation of Mississippi River	4,848 09
Level and topographic survey	6,890 80
Hydrographic survey near Piasa Island	1,507 85
Survey at Cairo protection	220 75
Water gauges, including the $192.15 reported above for gauges between the Illinois and Missouri	282 15
Total	15,749 64

An allotment of $5,000 has been made for the purpose of continuing the work of leveling and correcting the topography from the appropriation of June 14, 1880.

Operations will be resumed as soon as the stage of the river will permit.

One of the most important developments of this survey is the evidence which the present position of the shore lines affords, that the stability of the banks has decreased with the settlement of the country and the clearing away of the forests. Weakened banks permit more rapid erosions, give the river greater width, and therefore less depth, and the navigation is injured. The fact that the river has materially widened within the last 60 years is generally acknowledged by those best informed, but all evidence that can be procured in support of it is useful in resisting claims for damages, by establishing the position that our works of improvement are works of conservancy. And if this widening process is still going on it is evident that the navigation is still further deteriorating. An examination of the shore line shows that in every case where cleared fields along a caving bank are interrupted by a patch of woods the latter projects out into the river. It is easy to believe that the binding quality of the roots, and the protection formed by the fallen trees at the foot of the bank should have this effect. Wooded banks yield finally, of course, but the rate of erosion is so slow that the river has time to build up on the opposite side, and there is no increase of width. Four extracts from Mr. West's maps, selected at points which had been previously covered by authentic surveys are submitted in illustration of this point.

Extract No. 1 shows the shore line opposite the mouth of the Missouri as it was in 1870 and in 1879. In nine years the caving at the upper end of this ground, where the bank was stocked with woods, was almost nothing; at the middle portion, the ground being cleared, there was an erosion of over 900 feet, and at the lower portion where woods are found again there was from 100 to 200 feet of erosion. No. 2 shows a wooded bank just below Carroll's Island, as it was found in 1872 and in 1879. It has been exposed to the attack of the main channel for seven years, and the erosion is nowhere greater than 200 feet, and in some places is less than 20 feet. No. 3 shows a bank alternately cleared and wooded just above Kimmswick, as it was found in 1873 and in 1879. An erosion of 1,600 feet in the deepest part where the bank is cleared has occurred in six years, and the river has been widened that much. The wooded point at the lower end has held on in a remarkable manner. No. 4 exhibits Fish Bend, where the erosion has been more rapid than at any other point covered by Mr. West's survey. Nearly 2,000 feet has been washed away in the deepest part in the five years since 1874. The prominence of the

patch of woods, marked A, near the middle of the bend is apparent to the eye. The next patch below, marked B, though at first glance its prominence is not so apparent, has held on so as to make the river at this point narrower than at any other within these limits. The survey of 1874 gives only one bank of the river.

The facts of which these are examples lead to the belief not only that the navigation has been deteriorating in the past, but that the process is still going on, and will increase in rapidity as further clearings are made, and that, unless energetic measures are adopted to replace the guards established by nature and removed by man, the day will come when the navigability of the river for vessels that now use it will be destroyed.

EQUIPMENT.

The greater number of the works in this district being situated at points where it is impracticable to procure suitable boarding accommodations for the force employed, it is necessary to provide public quarters. To construct buildings on shore would necessitate the acquisition of land and the services of a keeper throughout the year when the work is suspended, and in many cases the buildings would be needed but a short time. A better arrangement is to provide floating quarters which can be moved from point to point, and be brought together for safe-keeping with the other property when the work is suspended. Two quarter-boats having a capacity of 48 laborers each, with the necessary kitchen and office room, and with accommodations for the overseer, &c., were built at a cost of $2,000 each. It is proposed to gradually increase the number of these boats as appropriations are made.

Barges No. 4 and No. 6 having become unserviceable, were condemned and dropped.

The hull of the steamer Anita is nearly worn out, but can probably be made to answer through the coming year.

RIPARIAN RIGHTS.

One of the most important questions connected with the improvement of the Mississippi River is that of riparian rights. The reasons why it is of special interest to the Engineer Department are that under the present frequent, if not general, interpretation of the common law: 1st, the boundary between private property on the banks and the public highway is not defined, while it is of great importance that it should be defined if the government is to be held liable for damages caused by its works, and it is important in any event in order to avoid trespass; 2d, the accretions caused by the works belong to the owner of the adjoining land, while it is absolutely necessary that the government should control these accretions for a considerable period after they emerge from the water; 3d, the United States has no title to alluvial islands formed by nature, or to lands reclaimed by its works, while it requires such lands for the cultivation of willows, and should in equity fall heir to them as they are formed.

It is uncertain how far the laws declaring the Mississippi a public highway have impaired the right of private ownership of the bed. Of the two States bordering upon my district, the courts of Illinois hold that this right still exists; those of Missouri that it does not. The Supreme Court of the United States has decided that it does, and again that it does not. But I believe that a majority of the States hold that it does, and this must probably be considered the present law of the land.

It cannot be considered good law, because it is not good policy. The reasoning by which the adverse decisions referred to were reached was probably based upon the supposition that the public requires only a *passage over* the bed. That is not the case. The public requires to go down *to* and *under* the bed to establish substantial works upon it and to keep them there forever. It requires to remove the water from parts of the bed, and to put such parts to its own uses for an indefinite period. If the right of private ownership is recognized, the United States can do nothing without trespassing upon private property; there can be no further argument as to the ownership of accretions or "tow-heads," and it is in the power of any ignorant or malicious riparian owner to place endless obstacles in the way of the improvement.

Considering the bed as a whole, the question of ownership is of far greater interest to the United States than to any individual, for to the former it is a necessity as the site of its works, while to the latter it is of little practical value. But at the margin of the stream the interests are more nearly equal. Concedeing that from the nature of the case it is necessary that the government (whether State or national) should own the bed of the stream, it remains to define what is meant by the bed, and to fix a boundary between the public and private property. This boundary is necessarily a movable one, and must be the water edge at some given stage, a low, a high, or a mean stage. The question has been decided in France according to the old Roman law, "*ripa ea putatur esse quae plenissimum flumen continet*," and there the bed comprises all the ground covered by the water when it has reached its greatest elevation before overflow.

Whatever elevation the waters may reach, so long as there is no overflow or flood they are within their own domain, and this is properly considered the bed. The question of determining the exact level at which flood begins at any locality is left to the executive. This arrangement has worked well there, and would probably work equally well here.

The contraction of the river, where it is excessively wide, results in the formation of considerable bodies of reclaimed land. It is necessary that this land should remain under the exclusive control of the government for an uncertain number of years, until by successive deposits from the river it has been raised to a height at which, with suitable protection, it is secure from ever becoming again the site of the river. As riparian rights are now interpreted, these formations become the private property of the adjoining land owner as soon as they emerge from the water. This doctrine seems fair enough when the accretions are the result of natural causes, but when they are the result of large expenditures of money, its fairness is questionable. The accretions may be an injury to the riparian owner by removing from him water for his animals and his land; but from the nature of the case they would not be caused in any but places that are already shoal or liable to become so, and could not cut him off from *navigable* water any more than the shoals did before. On the contrary, by giving him a right of way across the new-made land, his approach to deep water would be facilitated.

It seems to me that the small injury of compelling him to go somewhat further for his water is one of those that the individual must always be ready to suffer for the benefit of the public, and that if a right of way be allowed across the new land to the river, no injustice will be done in declaring these reclaimed lands the property of the United States. This question has been solved in a different way in France, by fixing as the boundary between public and private property the water-edge at a high stage. The new-made land thus remains under

the exclusive control of the government until it has reached a height at which it can be cultivated. It then reverts to the adjacent proprietor, the right of the government to exact an indemnity being recognized. Probably this solution would be a less shock to legal prejudices than for the government to assume the ownership outright. The indemnity exacted, however, could only be the difference between the value of the land before improvement and that after. The former being nothing, the financial result to the riparian proprietor would be the same under either solution.

Aside from the necessity, from an engineering point of view, of controlling the reclaimed lands for a series of years, they are of great value to the government in the cultivation of the willows, which are a vital necessity of the improvement. The supply of willow brush in the wild state is limited. There is even now no great surplus, and if the operations should be extended there will be great difficulty from this source. At present the price is low, but it would not be difficult for an enterprising individual to secure such a monopoly as would enable him to exact a price many times as high. The only safeguard against exorbitant prices or a failure of the supply altogether is to own willow plantations. Now the means by which it is expected to cause deposits upon the reclaimed land, and thus raise it to a secure height, is a plantation of willows. We have therefore not only made the land, but we have also stocked it with a growth that is of great value to us for improvements elsewhere. There is every reason, then, why the government should take possession of these lands if it can be properly done.

Alluvial islands of recent formation, or, as they are generally known upon the river, "tow-heads," are of equal value to the United States for this purpose, and of no value whatever to any other person, unless the United States becomes a purchaser of the product. These belong either to the owner of the adjacent land or to the riparian State, but in no case to the United States. A title to them could be obtained from the legislatures of the riparian States if it is once settled that they belong to those States. But looking at the subject independently of the law, it would seem that these formations should belong to the United States, because they are of value to it and to no one else, and because in exercising its power of conservancy it often finds it necessary to assume ownership to the extent of removing parts of them as public nuisances; also, because it is often practically impossible, in a stream a mile wide, with a frequently-shifting channel, to tell to which one of two opposite States the formation would belong.

It seems to me that these various considerations should receive the attention of the government now, while the interests at stake are comparatively small. The rectification of the Mississippi River will give an intrinsic value to ownerships which are now but little more than leases. The value of the principal product, willows, now almost nothing, is increasing, while increase of the population must necessarily increase the value of the land. To leave them to work their own solution in the common law is at best an expensive method, and judging by some recent decisions it is one which may result in rendering a prosecution of the improvement impracticable. The difficulty can be solved by legislation declaring the bed of the river a part of the public highway, and therefore public property, and defining the bed to be all ground lying below high-water mark, the determination of the exact line which shall be considered high-water mark at any locality being left to the executive. It is respectfully recommended that steps be taken to secure such legislation.

DAMAGES CAUSED BY THE WORKS.

Closely related to the foregoing is the question of damages to riparian owners, caused by the works of improvement. Although its settlement may not be within the reach of legislation, its present discussion will be profitable if it shall be found that the government can properly assume a position opposed to all such claims. Having taken up such a position, no opportunity should hereafter be lost to obtain and record evidence which may affect it.

Engineering operations upon the river, though they will eventually benefit all riparian owners, will at first affect some of them favorably and some unfavorably. One man's property will be washed away, while another's will receive accretions. One water front will become inacessible, while another will receive the main channel. These changes are constantly occurring in the course of nature, and are submitted to now as inevitable. But when the losses can be charged to the operations of the government, the sufferers will be less placid. If engineers are working in the vicinity the changes will be attributed to them, whether rightfully or wrongfully, and claims for damages are to be expected.

In an opinion of the Attorney-General, Mr. Caleb Cushing, dated October 19, 1853, it is shown that while the jurisdiction and ownership of the shores and bed of a navigable stream are vested in the States and not in the United States, "a power exists in the Federal Government—a *jus majistaticum*—for the conservation of the public rights of navigation and commerce," and he remarks that "the power to regulate the use of the shores and beds of navigable waters, so that the lawful purposes of commerce and navigation shall not be hindered, is quite distinct from the right of eminent domain."

The subject under discussion by him was the power of the United States to prevent the construction *by man* of a nuisance in a navigable water; but it seems to me that the application of the principles laid down may be extended to such natural but temporary nuisances as are constantly being constructed by a silt-bearing stream like the Mississippi. Among these are snags, islands, "tow-heads," bars, and other shoals. Indeed, such application is tacitly recognized by the appropriation of money for the removal of these nuisances.

But the government is liable in these operations to be considered as acting on the offensive instead of, as is the fact, on the defensive. The distinction is a very important one, when the claims for damages by riparian owners are under consideration. If the works of improvement are works of conservancy, and are planned so as to do no willful and malicious injury to an individual, there can be no valid claim for damages. If on the other hand a new state of affairs, never known before, is being produced, and the water highway is really being made better than it ever was before, and to the injury of a riparian owner, as in a slackwater improvement, damages may properly be claimed.

The shoals in the Mississippi are constantly shifting their position, and there are very few spots now occupied by them where there has not been deep water within a recent period. It is pretty well established that there was in former years a depth of water throughout the navigable channel at the lowest stage at least equal to what we shall endeavor to obtain by our works. It would of course be impossible to show that the form given to the river after improvement was the same as that it once had, but it would be sufficient to show that only the works necessary to remove the nuisance and to keep it from returning had been constructed.

It is a fact that we are not attempting to make an unnavigable river

navigable, nor even to obtain a greater depth at any given point than often naturally exists there. Although the river as a whole may, when the work is completed, be in better condition than it ever was before, and the character of the stream *as a whole* is thus being altered, the same cannot be said of any small portion of it. Considering a section bordering upon the property of any individual, our object is simply to restore what once existed, and to do it in such a way that the restoration shall be permanent. The river may, for this purpose, be compared to a railroad constructed originally with two steep slopes in its cuts. Constant slides obstruct the use of the highway. A removal of the obstructions and a correction of the slopes put the road as a whole in better condition than it ever was before; yet these are strictly works of conservancy. There is no doubt, therefore, in my mind, that all works of improvement of the general navigation to the extent of obtaining a channel depth of 10 or 12 feet below Saint Louis at the lowest stage may be properly regarded as works of conservancy.

This view of the matter can work no hardship to the present riparian owners. As before intimated, no man who now possesses a deep-water front can count upon long retaining it; nor can the owner of land be assured of any period during which the river will leave him in possession. He holds his property with this understanding, and it is valued accordingly.

CONTRACT SYSTEM.

All work during the year has been done by hired labor and the purchase of material in open market. It is intended to continue this system during the coming year, as the work here cannot be done by contract without injury to the public interest. Both systems have been tried, and the contract system has been found the more expensive of the two. (See Annual Report of the Chief of Engineers for 1877, page 514.) But a consideration of still greater importance is that the present system enables us to make advances in the art of river improvement which would not be practicable under the contract system. The *plan* of the improvement is one thing; the *method of construction* is another. No change is contemplated in the former. It is the plan recommended for rivers of this character by every engineer of repute from the time of Frisi to the present day. It is in brief to concentrate all the waters of the river in a single water-way of moderate width; that is, to close island chutes and contract the width of the river where it is inordinately great. It is the plan lately recommended by the Mississippi River Commission, and there is no presumption in saying that it is the only possible plan by which the navigation can be improved. But the methods of construction have been greatly altered and improved. Using at first, in 1873, the method successfully employed upon some of the largest European rivers, we have by successive steps developed a totally different system, as is shown above in the description of the works at Horsetail. Each step forward has been an experiment, and to this the contract system would have been directly opposed. The present method is considered good, but it cannot be asserted that no further advances are to be made, and until that becomes practically the case, the contract system will be an injury to the interest of the government.

The treacherous foundations of the Mississippi render it necessary that the engineer should have full liberty to change his plans whenever necessary; the varying height of the water makes it essential that he should be able to push his work or to slaken it according to circumstances; and the superior building power possessed by the river at one season

compared to what it possesses at another, renders the season of the year at which the work shall be energetically pushed far from a matter of indifference. The engineer in charge must, therefore, have full control of his works and all their details.

To place their execution in the hands of a contractor would almost certainly involve failure. Even if this were not the case the contract system would necessarily increase the cost. There are serious difficulties in the way of preparing specifications. All estimates are necessarily uncertain.

As the conditions change, the character of the work is liable to change. If the water becomes suddenly deep a different form of construction is required from what would be used if it remained shallow. A shifting of the channel, or other causes, may make work difficult which promised to be easy, and *vice versa*. Knowing these risks, responsible contractors will not bid without a wide margin of profit. The result is either to pay a high price for the work or to throw it into the hands of irresponsible persons. The latter would probably be the more usual result, and it would in the end be far the more costly. The forfeiture of bonds is a poor return for the damage caused by the loss of a working season and the possible necessity of preparing new plans, involving the removal of work which, in competent hands, would have proved beneficial, but which has become an obstruction to navigation. It may be said that a careful scrutiny of the business reputation of bidders will prevent the latter evil. The answer is that between those persons who are well known to be responsible and those known to be the reverse there is a wide field of character, containing all grades of honesty and capacity, and that many bidders may be found to whom no valid objections could be raised in advance, but who would, nevertheless, hold a position in the business world far below what the work on this river requires. And it should be borne in mind that the field is open to all of them. The character of the work is totally different from that being executed by any private individual in this country. If a bidder could come prepared with his plant and with experience in similar work elsewhere, there would be a fair chance of his shutting off many of those who have neither; and there would at least be a pretext for awarding him the contract, even when lower bids had been received from others. But here no one has the experience, and few, if any, have the plant. With competition under these circumstances there can be but one result, and that is to award the contract to the person who, groping his way in the dark, is willing to take the greatest pecuniary risks with the least profit as inducement. It is not reasonable to expect that that person will be the one who will have the inclination and the power to carry out his contract at any and all costs to himself.

APPROPRIATION OF JUNE 14, 1880.

The allotments made from the appropriation of June 14, 1880, amounting to $250,000, were, for—

Repairs and contingencies	$10,000
Levels and topography	5,000
Horsetail Bar	150,000
Cairo protection	5,000
Located by Congress	20,000
Total	190,000

Which leaves a balance of $60,000, available for beginning a new work.

The two worst places between Saint Louis and Cairo are in the vicinity of Widow Beard's Island, between Carroll's Island and the mouth of the Meramec, and just below Kaskaskia Bend. The least depth of water found last autumn at the former was 4 feet 4 inches, and at the latter 4 feet.

The changes going on at Kaskaskia Bend and just above render it impossible to foretell what the shape of the river will be in a few years from this time, and what will be the line of its approach to any works which might be planned for the improvement of the locality mentioned.

Attention will therefore be turned to that portion of the river lying between Carroll's Island and the mouth of the Meramec. A survey of the locality will be undertaken as soon as the river has fallen to a suitable stage, and a plan of the works required, with an estimate of their cost, will be submitted as soon afterwards as practicable.

COMMERCE TO BE BENEFITED.

It is not practicable to give with accuracy the amount of commerce that will be benefited by the completion of this work. The statistics collected by Colonel Simpson in 1877 showed that the value of the commerce which actually floated upon the Mississippi between the Illinois and Ohio rivers was then $178,000,000, exclusive of the value of vessels. This evidently is no measure of the commerce to be benefited, since the rates by river affect the rates by rail. A considerable part of all the commerce of the Mississippi Valley, whether by land or water, must be benefited by the improvement. There are no reliable data within my reach for estimating the value of this commerce. It has been estimated by some persons at $5,000,000,000. Much of this is independent of the river, and the value itself may be too high or too low; but, without claiming any approach to accuracy, the figures serve to give a general idea of the magnitude of the interests involved. If they be divided by 10, a value of $500,000,000 will still remain, and this will undoubtedly fall below the truth.

ESTIMATE FOR YEAR ENDING JUNE 30, 1882.

It has been shown in the annual reports from this office that the great difference between the annual estimates and the amounts appropriated would result in very much overrunning the total estimate before the work is completed; and the opinion was expressed last year that, with annual appropriations of $200,000, as have prevailed, the final improvement would cost $20,000,000 instead of $7,684,000, as estimated, and would occupy a century. Two hundred thousand dollars is less than 3 per cent. of the total estimate; and $250,000, the amount of the appropriation for next year, is about 3¼ per cent. As 2 or 3 per cent. of the total cost would not be an extravagant estimate for keeping the works in repair after they were once wholly completed, it is evident that the time and the cost given above are rather under than over stated. The estimate of $7,684,200 was submitted in 1876, previously to which time $725,000 had been appropriated, leaving $6,659,200 to be provided. The annual appropriations since that date have varied from nothing to $250,000. There is, therefore, reason now to add to the original estimate, but it is retained for the present with the hope that enlarged operations and improved methods will render it possible to recover the ground lost. There remained to be appropriated on the 30th of June, 1880, $6,039,600. Leaving out of account the immense financial advan-

tages to the government and the public which will result *annually* from securing cheap through transportation at the earliest possible moment, it may be stated that the work will be accomplished with the least outlay by six annual appropriations of $1,000,000 each. The less the annual appropriation the greater the final cost. I therefore submit an estimate of $1,000,000 as the amount that can be advantageously expended during the year ending June 30, 1882. And, in order that this sum may produce the greatest results, it is of the highest importance that it should be applied exclusively to the works of primary importance to the navigation interest. To expend any considerable portion of it at this time in the protection of local interests, as at Alton, Kaskaskia, Cairo, and similar places, must evidently be injurious to the interests of commerce. It is desirable that such of these works as Congress thinks proper to prosecute at this time should be provided for separately. Separate estimates for those which have been begun, viz, Kaskaskia and Cairo, have been given under their respective headings. These aggregate $100,000, which is added to the amount required for the navigation interest, making $1,100,000 in all. It is proposed to employ this sum in completing the works now progressing and those to be begun at Piasa and Widow Beard's islands, and in beginning works near Herculaneum, Platin Rock, Fish Bend, Fort Chartres Island, Jones's Point, and Hat Island, of which detailed estimates cannot be given in advance of the survey required for the actual beginning of each work. It is possible that obstacles may be developed at other places before that appropriation becomes available, which may be worse than those now existing at the points mentioned. In that case the programme given would be modified.

In submitting this estimate attention is again invited to the fact that the forces which have injured the navigation of this portion of the Mississippi are still at work. It cannot be stated too often or too plainly that the navigability of the river is in danger. The question involved is not simply whether better navigation shall be secured, but whether such as now exists shall be preserved. The works required to accomplish the one object may be made to accomplish the other. The longer the execution of them is postponed the more there will be to do, and, as before stated, the slower they progress the more they will cost.

The work is located in the collection district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1880, was $1,176,009.57.

Money statement.

July 1, 1879, amount available	$200,245 27	
Amount received for fuel sold to officers	30 00	
Amount appropriated by act approved June 14, 1880	250,000 00	
		$450,275 27
July 1, 1880, amount expended during fiscal year:		
By Col. J. H. Simpson, Corps of Engineers	127,118 66	
By Capt. O. H. Ernst, Corps of Engineers	38,396 55	
July 1, 1880, outstanding liabilities	1,421 49	
		166,936 70
July 1, 1880, amount available		283,338 57
Amount (estimated) required for completion of existing project		6,039,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		1,100,000 00

Construction account.

Name of work.	Expended previous to July 1, 1879.	Expended during year ending June 30, 1880.	Total cost to June 30, 1880.	Total estimated.	Required to complete.
Piasa Island Dam	$32, 333 30	....	$32, 333 30	$41, 210 73	$8, 877 [illegible]
Alton Dam	33, 623 92	....	33, 623 92	40, 000 00	6, 376 [illegible]
Sawyer Bend Protection	96, 803 63	....	96, 803 63	142, 211 62	45, 407 [illegible]
Venice Dikes	36, 341 85	....	36, 341 85	40, 000 00	3, 658 [illegible]
Arsenal Island Protection	9, 673 85	....	9, 673 85	9, 673 85	....
Closing Cahokia Chute	103, 149 89	$12, 938 71	116, 088 60	116, 088 60	....
Horsetail Bar, Dike 1	40, 549 53	....	40, 549 53	40, 549 53	....
Horsetail Bar, Dike 2	23, 600 26	....	23, 600 26	23, 600 26	....
Horsetail Bar, Dike 3	82, 692 54	....	82, 692 54	82, 692 54	....
Horsetail Bar, Dike 4	41, 290 11	....	41, 290 11	41, 290 11	....
Horsetail Bar, Dike 5	36, 933 87	....	36, 933 87	36, 933 87	....
Horsetail Bar, Training Wall and Hurdles	85, 241 21	85, 143 39	170, 384 60	320, 384 60	150, 000 [illegible]
Fort Chartres Dam	36, 812 86	....	36, 812 86	46, 562 86	9, 750 [illegible]
Turkey Island	24, 463 85	....	24, 463 85	32, 565 46	8, 101 [illegible]
Kaskaskia Protection	35, 437 86	18, 701 42	54, 139 28	258, 139 28	204, 000 [illegible]
Liberty Island Dam	5, 053 91	....	5, 053 91	5, 053 91	....
Liberty Island Protection	45, 129 40	....	45, 129 40	45, 129 40	....
Devil Island, Dike 1	65, 871 17	....	65, 871 17	} 150, 000 00	17, 601 [illegible]
Devil Island, Dam 1	49, 848 58	....	49, 848 58		
Devil Island, Dam 2	16, 678 30	....	16, 678 30		
Cairo Protection	85, 144 48	28, 206 95	113, 351 43	172, 500 00	59, 148 [illegible]
Totals	986, 674 37	144, 990 47	1, 131, 664 84	1, 644, 586 62	512, 921 [illegible]

Property and material account.

Class of property.	Balance July 1, 1879.	Dr.	Cr.	Balance June 30, 1880.
Office furniture	$172 05	$112 00	$60 00	$224 [illegible]
Instruments and survey material	1, 080 20	42 50	75 00	1, 056 [illegible]
Pile-drivers	4, 347 44	950 28	3, 687 00	1, 610 [illegible]
Barges	25, 880 01	3, 623 46	9, 434 23	20, 069 [illegible]
Two tow-boats, one launch, &c., and expenses	27, 710 52	31, 302 70	36, 888 67	22, 124 [illegible]
Small boats	145 26	505 98	250 00	401 [illegible]
General expenses of property	21, 437 00	1, 845 36	....	23, 282 [illegible]
Material and quarry privileges	2, 912 23	73, 438 52	73, 853 26	2, 497 [illegible]
Tools and appliances	644 63	3, 855 61	2, 635 23	1, 865 [illegible]
Quarters, shops, &c	4, 080 05	4, 795 32	1, 380 00	7, 495 [illegible]
Totals	88, 418 48	120, 471 73	128, 263 39	80, 626 [illegible]

Engineer Office, United States Army, in account with the United States.

To appropriations, allotments, &c., prior to July 1, 1879	$1, 443, 226 80	By expenses of office	$59, 351 [illegible]
To allotment from appropriation for examinations, surveys, &c	2, 000 00	By general engineering	34, 176 [illegible]
To appropriation for improvement of Mississippi River between Illinois and Ohio rivers, approved June 14, 1880	250, 000 00	By surveys	106, 098 [illegible]
To appropriation for improvement of Mississippi River at or near Cape Girardeau and Minton's Point, Mo., approved June 14, 1880	20, 000 00	By constructions	1, 131, 664 [illegible]
To appropriation for ice harbor at Saint Louis, Mo., approved June 14, 1880	50, 000 00	By balance on account of property, &c	80, 626 [illegible]
To cash for fuel, sold to officers	30 00	By cash on hand and in Treasury	354, 760 [illegible]
To unpaid percentage	900 17		
To liability for labor	521 32		
Total	1, 766, 678 29	Total	1, 766, 678 [illegible]

A.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *July* 8, 1880.

CAPTAIN: The following report of operations for the improvement of the Mississippi River at Cahokia Chute and Horsetail Bar during the fiscal year ending June 30, 1880, is respectfully submitted:

CAHOKIA CHUTE.

The dam across Cahokia Chute was broken on or about August 30, while the water was approaching the low stage. The breach after being fully developed was 300 feet wide with 24 feet maximum depth. Its location was eastward from a point 100 feet from Arsenal Island.

The revetment on Arsenal Island below the dam was seriously injured by the strong current pouring through the breach, which eroded the bed to great depths and undermined it. The dam had settled at several points along its length so that its crest presented an uneven surface and an irregular width.

The work of closing the breach was commenced on the 2d and completed on the 20th of September. In closing this breach large stone was used to break up strong currents and was found to be in the interest of economy. A considerable saving was made in the amount of material required by a change in the alignment, deflecting it up stream, so that the hole in which the maximum depth was found extended only into the lower slope instead of across the whole base of the dam, as it would have done had the dam been reinstated upon its original line.

After closing the breach the crest of the dam was dressed to an even surface and as nearly to a regular width as practicable at moderate expense. Its general elevation was left 9 feet above low-water with approaches at each end rising by gradual slopes to 14 feet.

A mat of brush was placed in the base of the revetment below the west end of the dam, and a revetment of stone was extended up the slope of the bank to about 12 feet above low-water. The bank above that elevation being vertical, or nearly so, was left to receive a slope by the action of the river at high stages before being revetted. All of these repairs were completed by the last of October.

The following statement shows the quantities and cost of material expended:

9,556.77 cubic yards stone placed as riprap	$12,280 65
118.09 cords brush	246 81
Engineering and contingencies	411 25
Total	12,938 71

HORSETAIL BAR.

The work of this fiscal year at Horsetail Bar was in continuation of the construction of the training wall, and the hurdles in rear of it.

During the two years immediately preceding, a section of the training wall was built between dikes Nos. 3 and 4, and another from the willow bar above dike No. 2 down stream, a distance of 5,950 feet, leaving a gap 2,500 feet long, which had an average depth of 22 feet with the stage of the river at 12 feet above low-water. To close that gap was the object of this year's work on the training wall.

On the map of Horsetail Bar, showing progress of work and the results obtained, this gap is shown between points marked P and Q.

Of the lines of hurdles shown on this map, all of those above dike No. 2, and the third one below the dike, were built last year.

The progress of the silting up, or the results obtained, may be seen in a general way by comparing the soundings which are shown on this map, after being reduced to the same plane, from surveys made at different dates, as follows: March 25 to April 4, 1879; January 26 to 28, March 5, 9, and 17, and June 29 and 30, 1880; or, better, by comparing profiles made from soundings which will be introduced in the details of the work.

The first-named survey extended only down to dike No. 3. At that time there was a hole below dike No. 3, 70 feet deep at low stages of the river; while below dike No. 2 a hole is shown 52 feet deep. Both of these had filled considerably before the operations of this fiscal year commenced, the former to about 50 feet, and the latter to 33 feet.

Training-wall.—In obedience to verbal instructions, estimates of the probable cost of closing the gap in the training-wall were submitted September 9, in which seven different forms of construction were compared, ranging in solidity between a solid

wall of stone placed in riprap on a brush foundation, as shown in estimate No. 1, to a permeable structure made by planting feathers upon a foundation mattress, as in estimate No. 7; and in probable cost between $100,000 for the structure contemplated in estimate No. 1, to $17,000 for that in No. 7.

The form proposed in estimate No. 7 was approved, and its construction proceeded with in obedience to instructions received per letter, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY,
"*Saint Louis, Mo., September* 9, 1879.

"SIR: Your letter of this date, submitting estimates of cost for closing the gap in the training-wall at Horsetail Bar, using various forms of construction, has been received.

"Your design numbered 7, consisting of mattress and 'feathers,' promises good results, and is worthy of a trial. You will please proceed with the work, using that form of construction, keeping careful notes of cost and results.

"By command of Colonel Simpson, and in his absence.

"Very respectfully,

"O. H. ERNST,
"*Captain of Engineers.*"

The following extract from the letter submitting the estimates, describes the essential features of design numbered 7 to which reference is made in the foregoing letter.

"ESTIMATE NO. 7.

"For a permeable structure, which may be made by planting a sufficient number of feathers on a foundation mattress to check the current and cause deposits.

"A feather may be made by taking two saplings as long as can be obtained conveniently and nailing smaller saplings or brush to them (see diagram 3 *a*) as close together as may be practicable throughout their entire length, and then it may be planted on the mattress while afloat by anchoring its butt end to the bottom grillage and attaching its top to a buoy. The buoys may be boxes, barrels, or booms formed of dry logs or driftwood."

Other details were given which may be omitted here, as they will be found in the description of the work actually done.

In accordance with verbal instructions, suitable floating ways for constructing and launching mattresses in place were prepared, using for this purpose barge No. 3, which had become unserviceable for the transportation of heavy material. To prepare the barge for the reception of the ways it was cut in halves after running bulkheads across on either side of the midship section, cutting the gunwales away to give the proper slope to the ways, and firmly connecting the parts together as shown in Fig. 1.

In Fig. 1, which is a perspective view of the ways, illustrating their form of construction, A A are parts of the barge connected together by the beams B B. The ways *a a a*, &c., project over the end of the barge to ease the mattress into the water, and at the opposite end a clear space was left on the barge for convenience in handling lines and material.

The ways had an available width of 58 feet, and about the same available length was all that could be obtained. A platform was suspended from the beams which supported the ways over the space between the parts of the barge, and a portion of the deck was left off the barge so that men could pass under the mattress while constructing it.

These preliminary preparations having been completed, the work of closing the gap was begun at the upstream end September 27, and was vigorously prosecuted from that date to December 15, when it was suspended on account of ice running in the river. It was resumed January 12, and continued until the close of the fiscal year with a greater or less force, according to circumstances, the force being regulated to some extent to suit the varying conditions of weather, stage of river, and state of available funds.

A permeable system of works has been adhered to throughout the year. The following forms of construction, however, have been tried experimentally: The mattress with feathers attached; the mattress, with curtains; and, without the mattress, the open curtain and the closely woven curtain. Each of these presents novelties which may make a special description interesting.

Referring to the accompanying tracings, Fig. 2 is a perspective view of the form of construction made by attaching feathers to a foundation mattress in which A is the mattress, E F are feathers attached to it by flexible connections, *c c* and B B are buoys, supporting the tops of the feathers at any desired height. Fig. 3 is an end view of the same, and Fig. 3 *a* is a cross-section of a feather.

The mattress A was constructed of a lower series of poles, *a*, attached to the longitudinal ties C; above the poles *a* longitudinal poles *b* were laid; above these two ties

Fig. 1

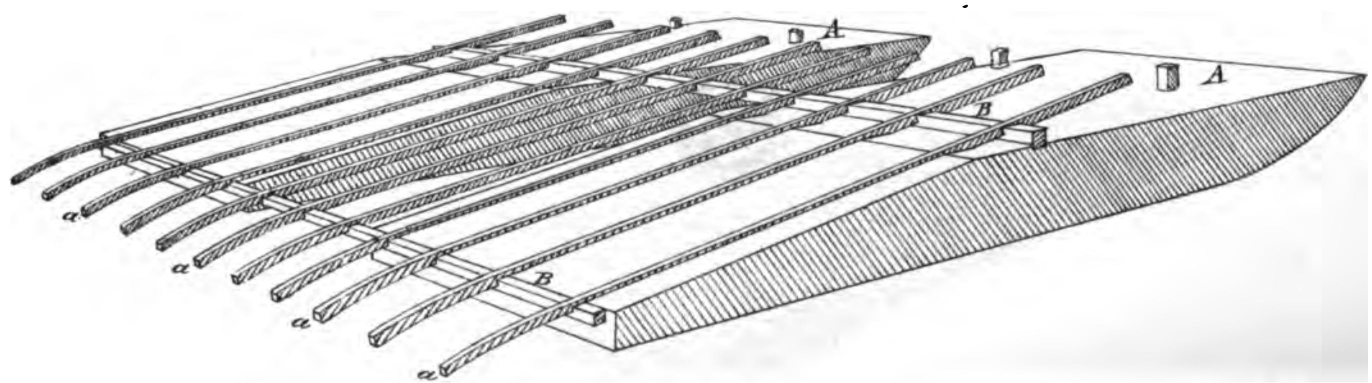


Fig. 2

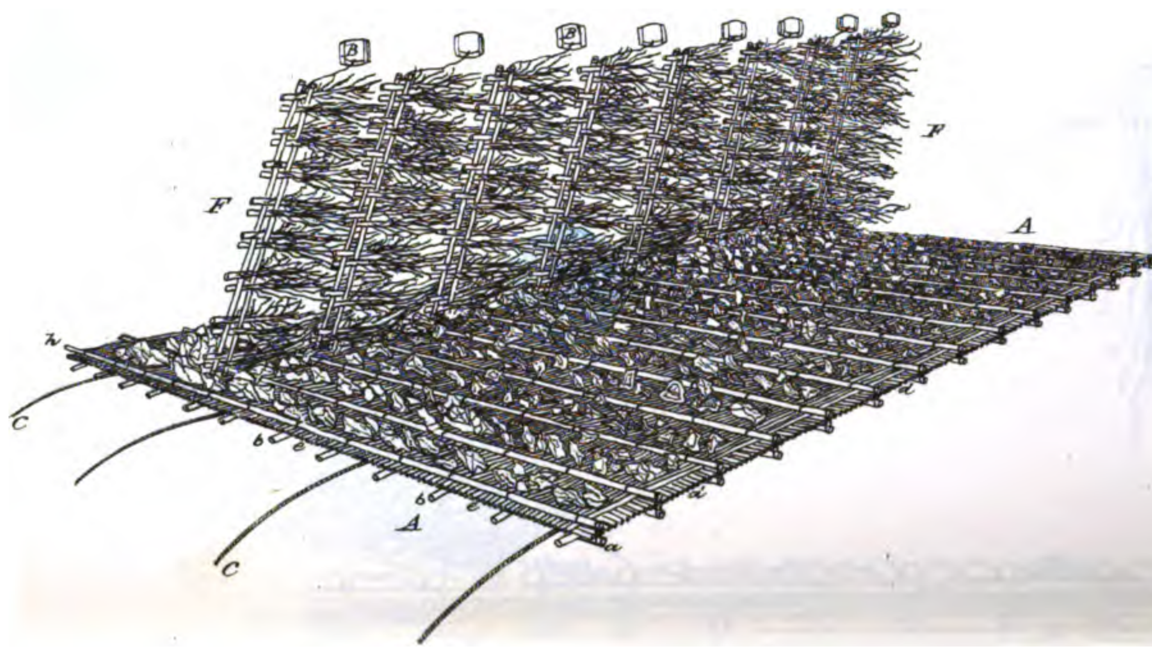


Fig. 3

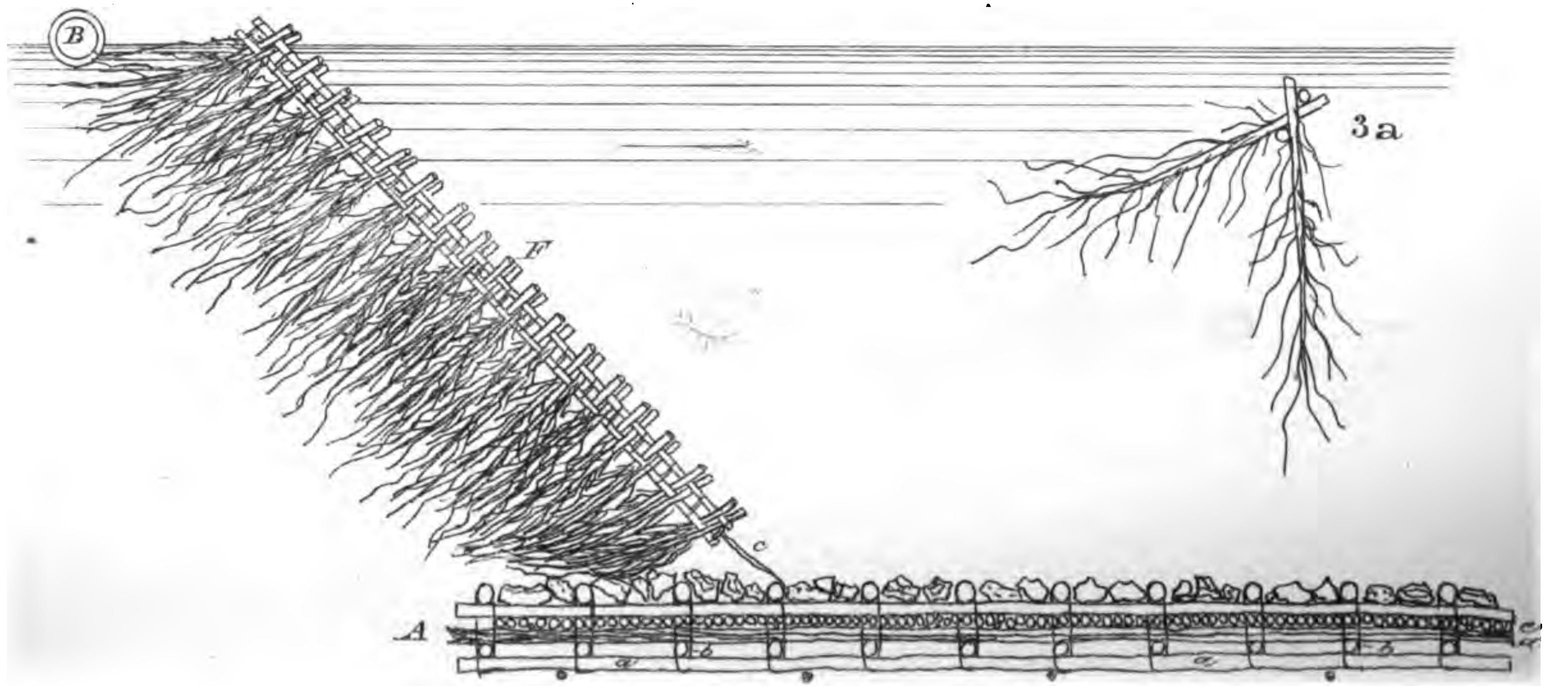


Fig. 4

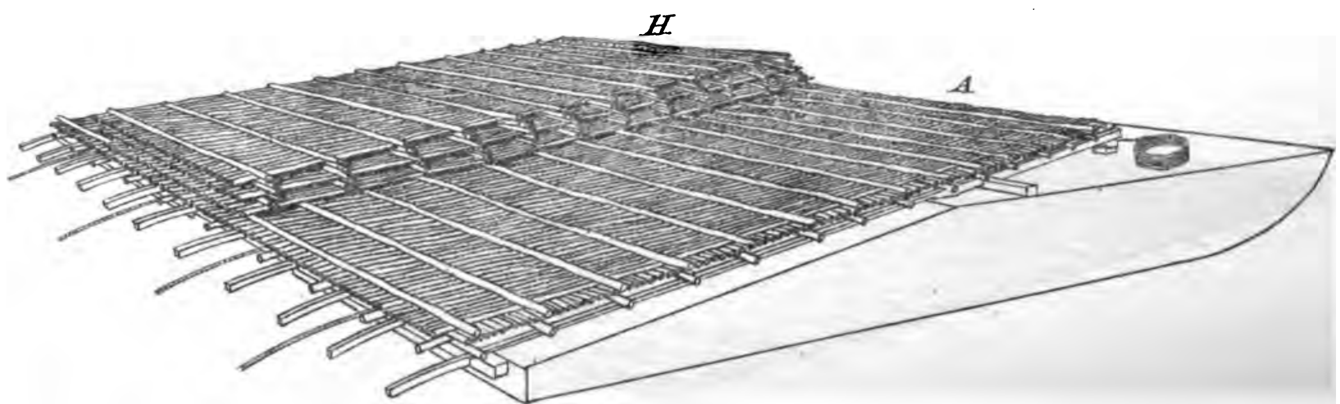


Fig. 5

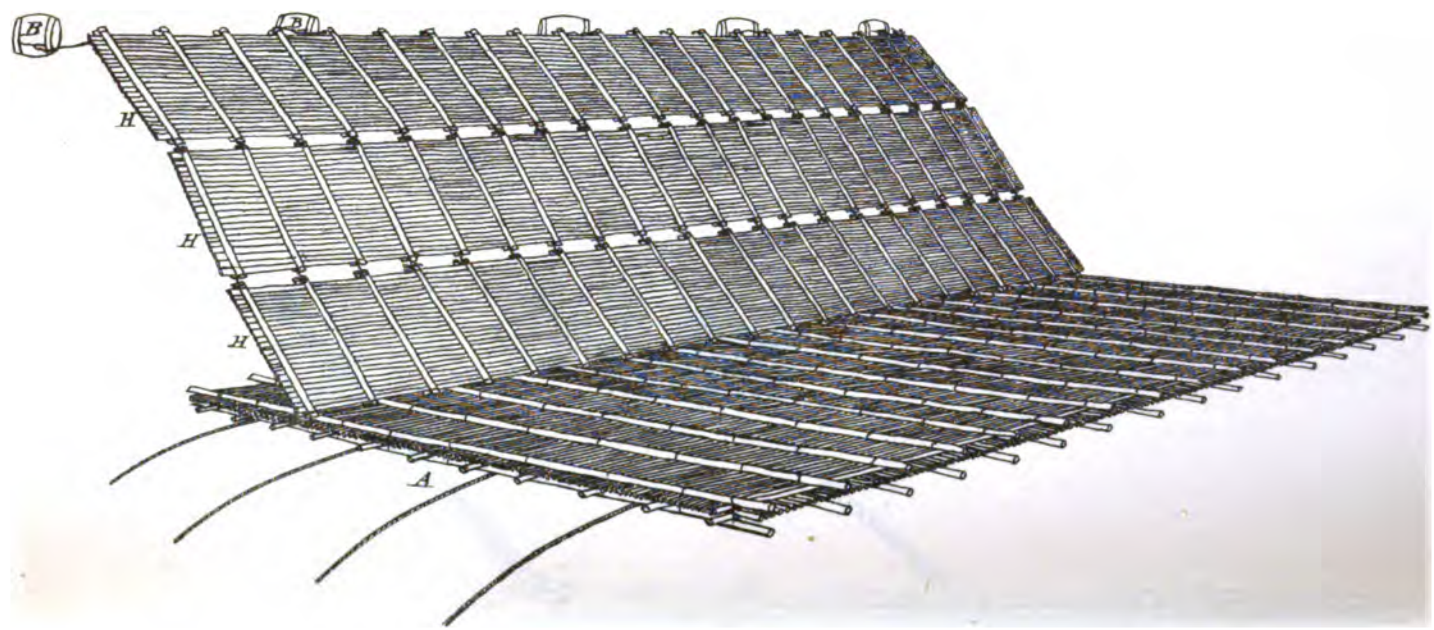


Fig. 6

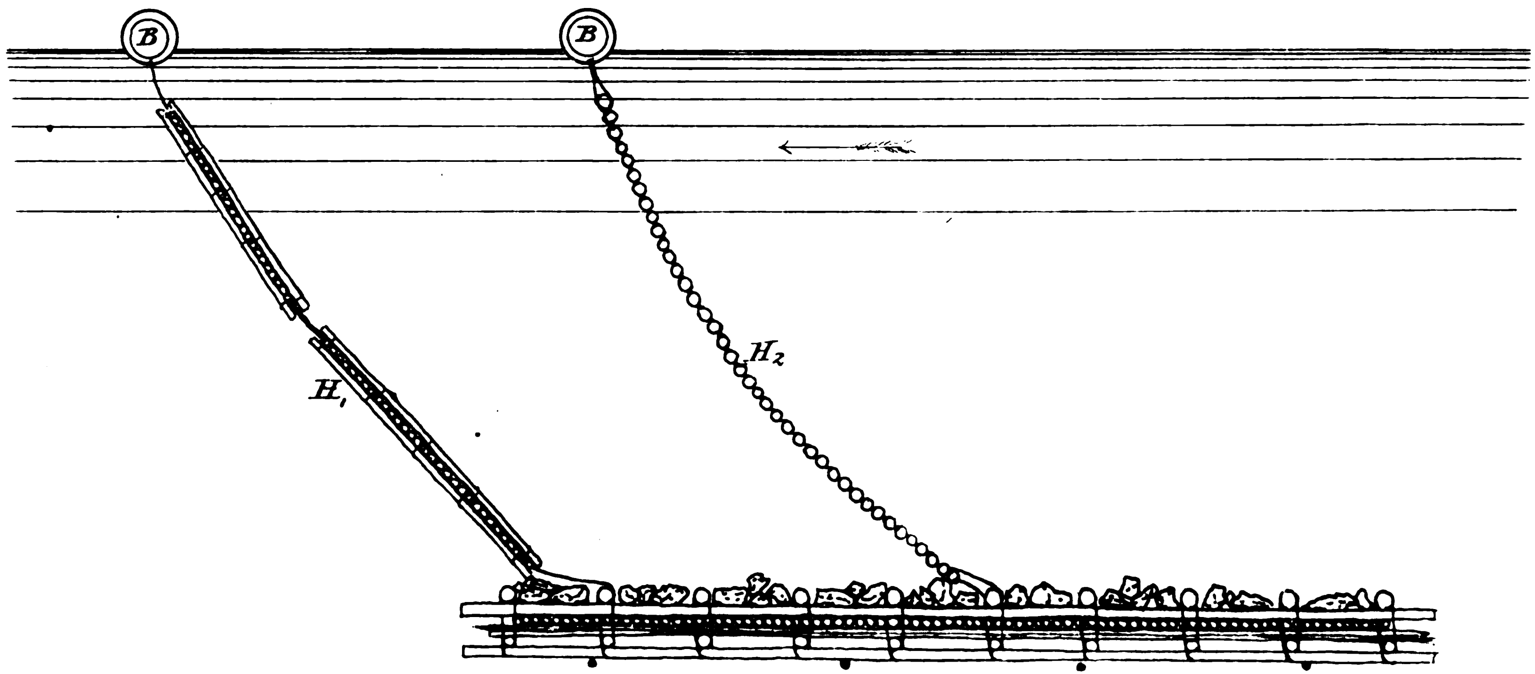


Fig. 7

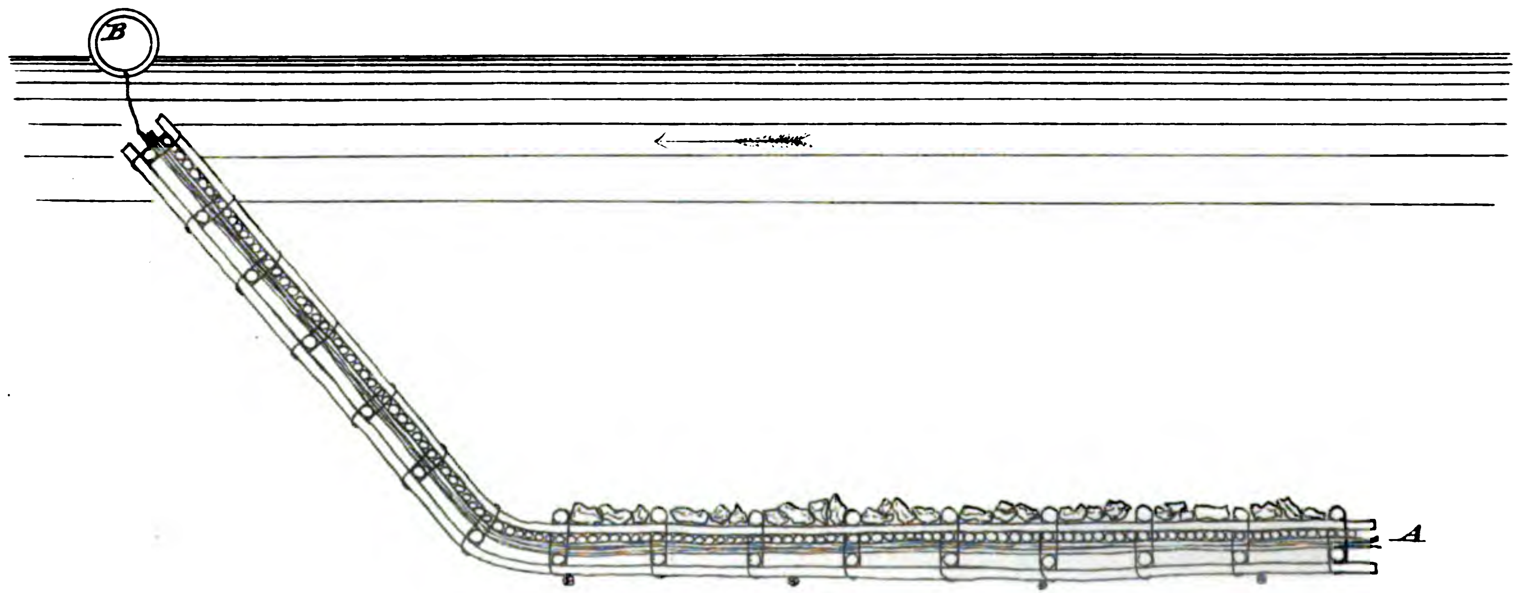
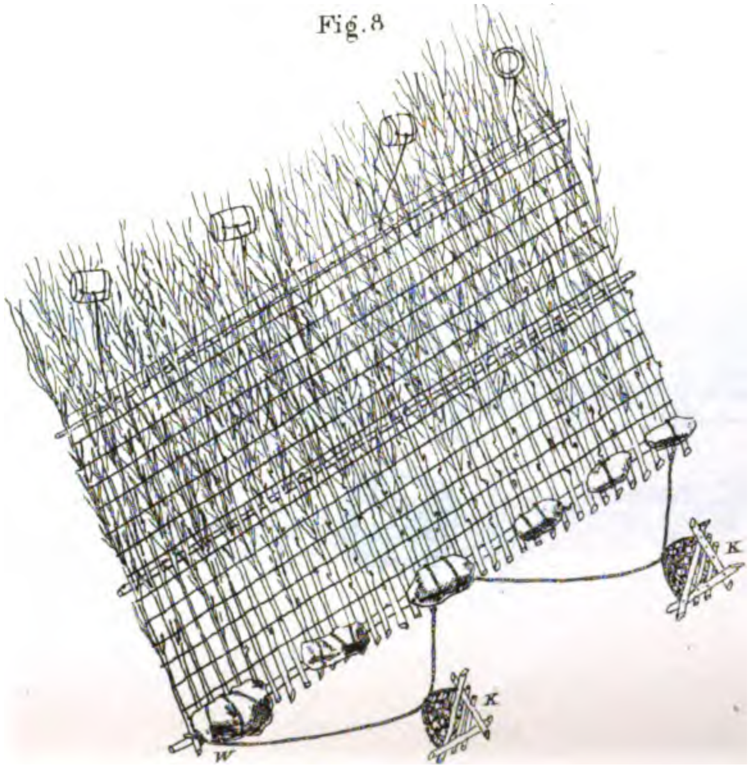
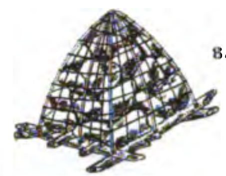
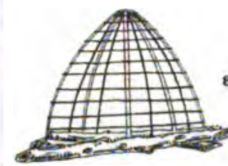


Fig. 8

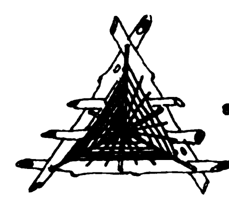




8a



8b



8c

Fig. 9.

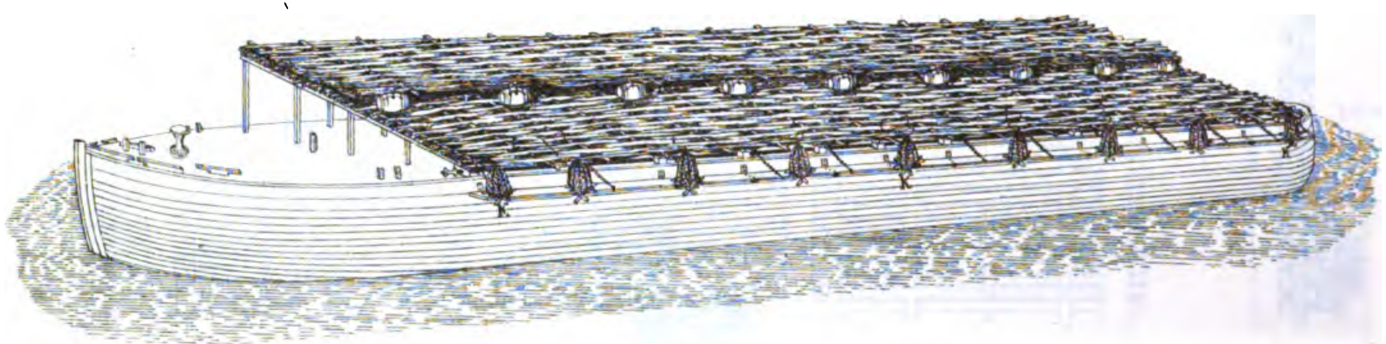


Fig. 10

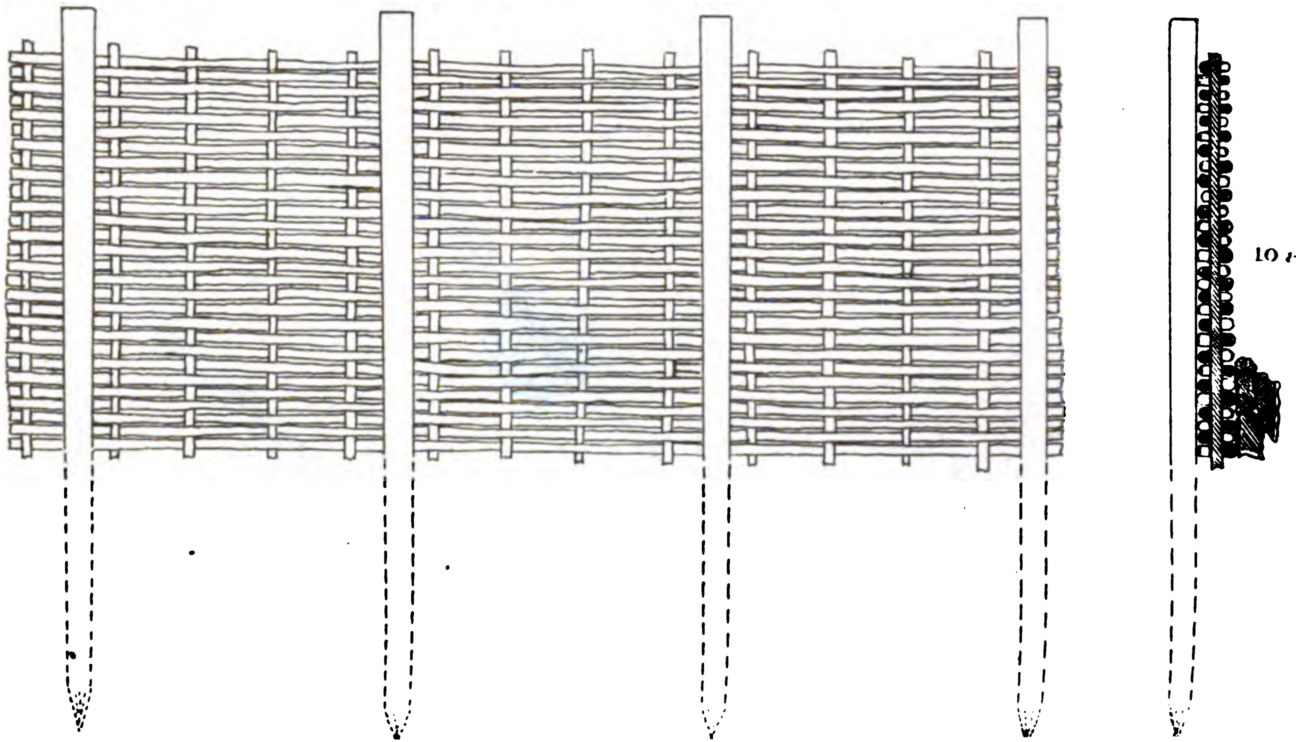


Fig. 11

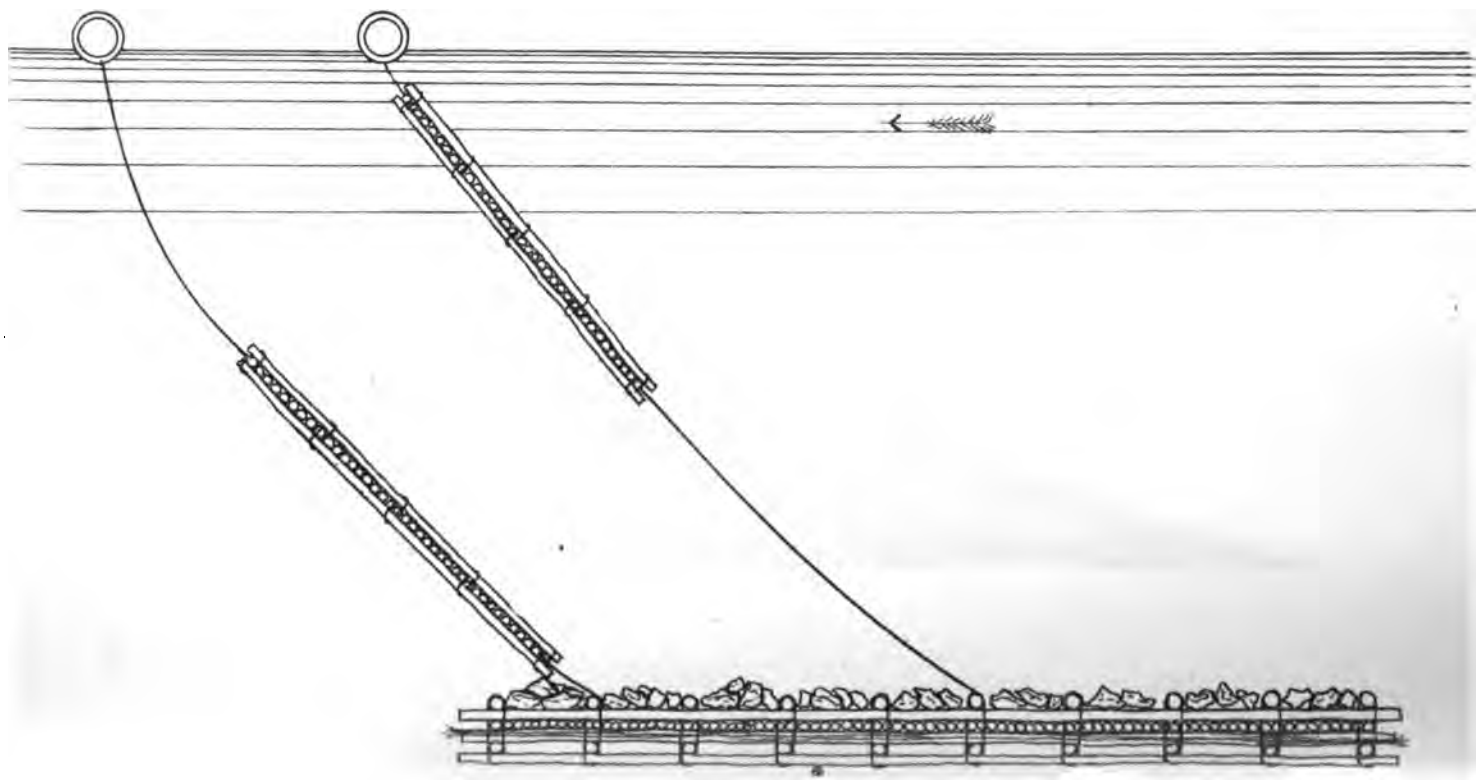


Fig. 12

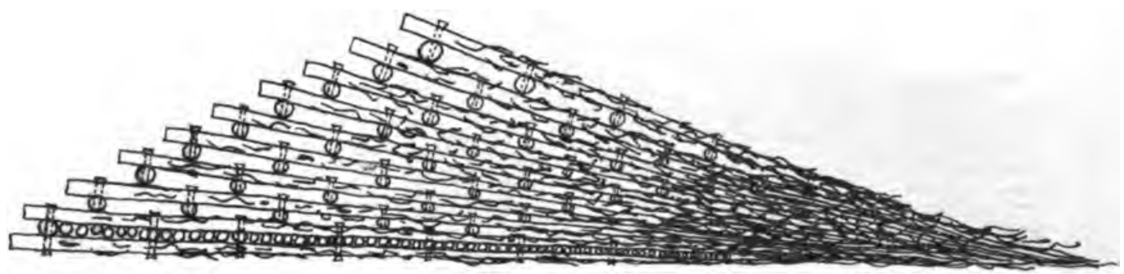


Fig. 13

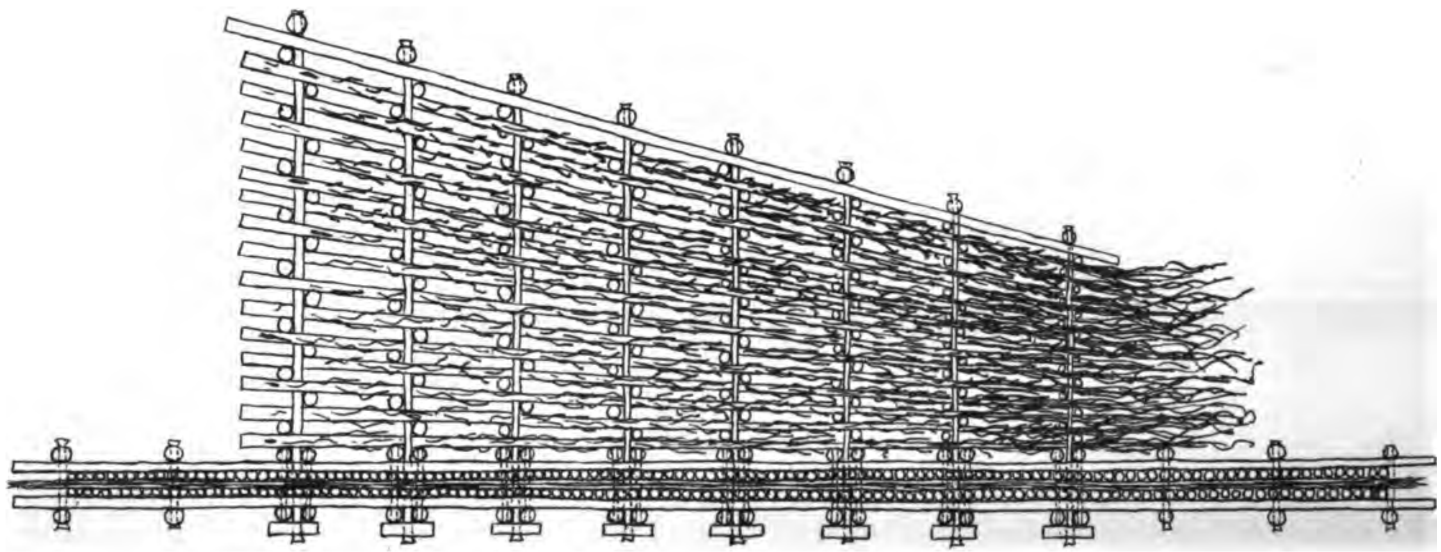
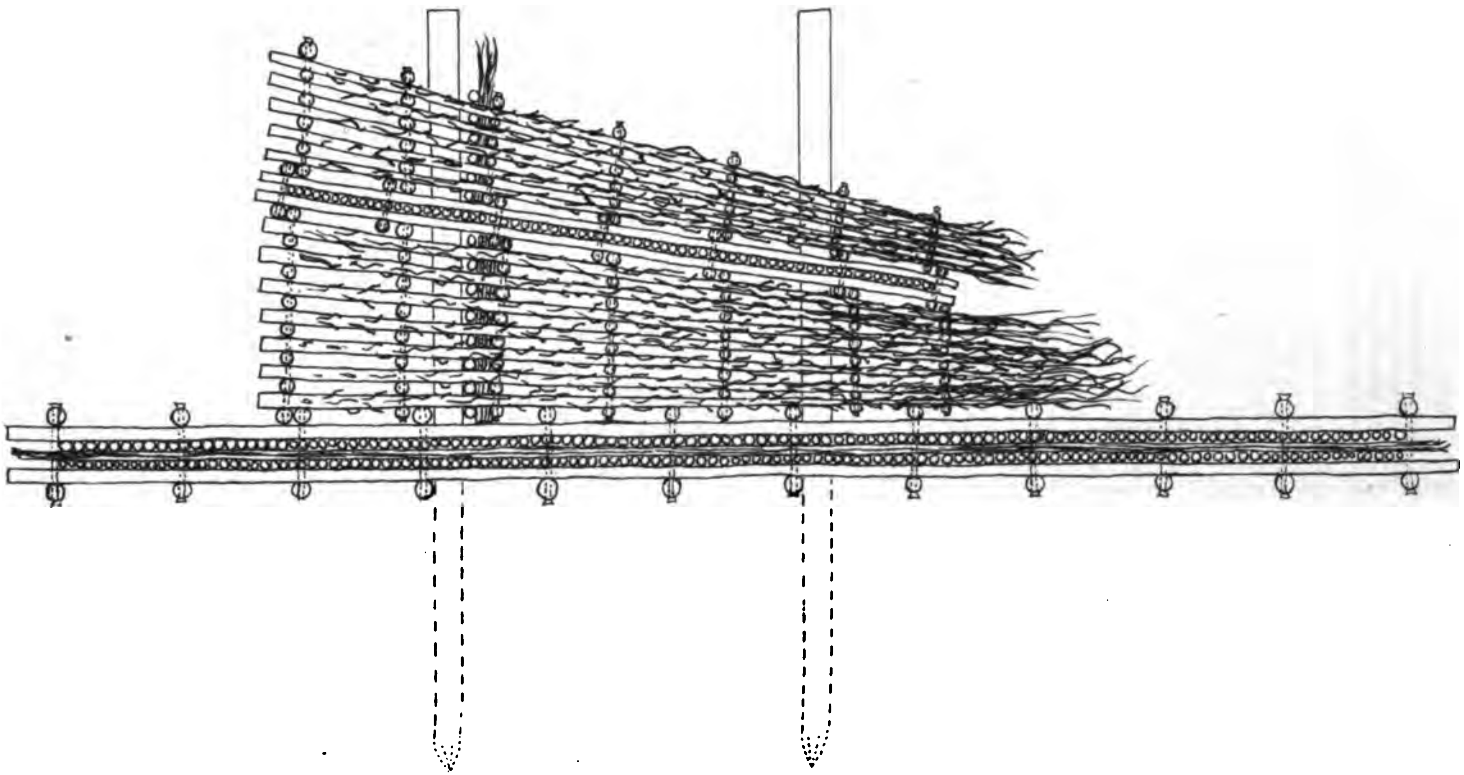


Fig. 14



of brush, *d* and *e*, were laid, crossing each other as shown; and above these a series of poles, *h*. The whole was bound together by wires or small lines of sisal, manila, or tarred rope passing through the mattress from the upper to the lower series of poles. Lines of sisal rope were, for economical reasons, more used than the others, though all were used experimentally.

The ties C were used to give tenacity and strength to the mattress, and to facilitate the ease with which it could be moved and sunk in long sections or continuously. To serve this purpose required that they should have tenacity and strength sufficient to resist the force presented by the different velocities, depths, and directions of currents, driftwood, and other *débris* incident to variable stages of the river, together with the weight of the ways and a floating section of mattress. They were usually four in number, of manila rope of from 4 to 5 inches in circumference, according to the forces they would probably have to resist.

Lines were also attached to the mattress transversely at suitable intervals, to be used in hauling it into position and holding it there while being sunk. These lines were so attached that they could be removed after the mattress was placed. This was done by weighting long sections of the foundation mattress with stone keeping always a short section afloat to keep up the continuity. Although the form of mattress herein described was that most generally used, other forms, consisting some of 3 tiers of brush, and some of only 1 tier were tried.

The feathers were attached at the most convenient time after the mattress was completed, regardless of the time of launching. They were made in place by taking two poles selected from the brush of larger size, having a length about equal to twice the depth of water, and nailing brush to them as shown in Figs. 2, 3, and 3*a*. Their butt ends were attached to the foundation mattress by means of small lines of sisal rope. These lines were usually about ¾ inch in diameter. Buoys made of second-hand water-tight barrels were attached to the tops of the feathers by means of lines of small sisal rope.

Although the feathers made and attached, as shown in the accompanying tracings and described in the preceding paragraph, proved to be an excellent device for the purpose for which they were designed, and especially well adapted for use in strong cross-currents on account of their freedom to swing in the current from being attached to the foundation mattress at a single point, as a consequence presenting a minimum surface to the action of the current, still their construction proved to be tedious and the progress made was slower than had been anticipated.

Experiments were therefore made with other devices for the vertical or inclined member in order to find some form equal to feathers in efficiency, which could be constructed more rapidly and at less cost. These experiments were successful and led to the substitution of a design which is described in the following extract from a letter amending the original design and asking authority to make further experiments, which was submitted October 15.

* * * * * * *

"Design for a mattress to protect the bottom against scour, combined with a permeable suspended component to check the current and cause deposits in the rear of it; said suspended component may be composed of feathers, weeds or curtains, or any combination of them, and should be attached to the mattress while afloat. The mattress when sunk will form the anchorage for the suspended component. Feathers were defined in the letter to which this refers. Weeds may be the Brownlow weed or any modification of it. Curtain, as used here, means a suspended mattress, and may be made in any of the usual forms having any desired degree of flexibility and permeability, and either in sections of any convenient length or continuous. An edge of the curtain having been attached to the mattress, the opposite edge is kept afloat by one or more buoys. The curtain and mattress may be constructed together by sinking one side of the mattress and buoying the other. In that case flexibility may be obtained by severing the mattress on the line of division of the sunken and suspended portions and connecting the parts by ropes, wires, or other suitable means.

"The sections may be made in two or more sections, vertically, in convenient lengths, and may be folded on the mattress for convenience in making and placing them, or they may be made to roll up after the manner of Venetian blinds.

"The mattress may be made in sections of any desired length or continuous.

"This design in some of its forms is applicable to the improvement of silt-bearing streams, as dams in closing chutes or other branches for the protection of caving banks below low-water, for contracting channel widths, and for giving direction to currents, and it may be used in either shoal or deep water."

Authority to make further experiments having been granted, the forms of construction shown in Figs. 4, 5, 6, and 7 were used experimentally. In Fig. 4 is shown a perspective view of mattress A, with curtain H, folded upon it on the ways to illustrate the mode of construction. The curtains were usually constructed, however,

after launching the mattress. Fig. 5 is a perspective view of the mattress and curtain after being placed.

In Fig. 6 an end view is shown of the mattress with 2 forms curtains H and H², H being the same as shown in Figs. 4 and 5, except that one section is left off. Fig. 7 shows an end view of the mattress with an edge supported at the desired height to form the inclined member. H and H are mattresses made in the usual form with one or two tiers of brush as was desired to suit the wants of each case. They were jointed and folded on the foundation mattress for convenience in handling during construction. H² was made by weaving brush on a warp of wire or sisal ropes. It was rolled up on the foundation mattress during construction and unrolled itself in placing it.

The forms shown in Fig. 2 to 7, inclusive, were used prior to December 1, and in location from the upper end of the gap down stream a distance about 1,500 feet. The foundation mattress was built in two sections, one extending 965 feet and the other from that to the lower point to which this form was used. A section of mattress with curtains attached went adrift during a storm November 18, and another section was lost December 1, while being placed. The stage of the river at that time was unfavorable for placing mattresses in long sections in that part of the training wall, the bars on the east side of it being submerged while the solid portion of the upper section of the wall was above water, which caused a strong current to set eastward across that part of the wall under process of construction, which combined with the improbability of having continued favorable weather after the 1st of December, made it inexpedient to continue the form of construction that had been used.

The construction of the training wall was continued with a light form of curtain in compliance with instructions contained in your letter dated December 2, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY,
"*Saint Louis, Mo., December* 2, 1879.

"SIR: In continuing the construction of the training wall at Horsetail Bar, you will please use during the remainder of the season a simple open work curtain without the horizontal mattress. This curtain is to be anchored to the bottom by stones, the upper side buoyed as before. It will be constructed of willow brush of the size now used, and it will consist of a single thickness, the pieces being placed 12″ apart from center to center, thus leaving an open space between the pieces of about 8 inches. The pieces will be so placed that they will occupy a vertical position when anchored. They will be bound together with wire as verbally explained to you.

"You are requested to prepare one of the barges for attaching the anchors and tripping them all together, as verbally explained to you. The curtains should be made in lengths as great as practicable to sink at one operation. The limit will probably be about the length of the anchoring barge.

"By command of Colonel Simpson.

"Very respectfully,

"O. H. ERNST.
"*Captain of Engineers.*

"Mr. D. M. CURRIE,
"*Assistant Engineer.*"

The work was continued with a single line of this open curtain until interrupted by ice, December 15, when it had been extended to the upper end of the lower section of training-wall, though not quite to the portion above water.

The last of these curtains was placed December 13, and had their buoys cut off soon after by ice, which commenced running heavily two days later, giving them an insufficient test.

The form of construction described in the foregoing letter and used from December 2 to 15, is shown in perspective with anchorage attached in Fig. 8, in which K are anchors, W weights of stone attached to the lower edge of the curtain. Pending the preparation of a barge, the curtain was constructed upon temporary ways erected on one of the barges by placing stage plank with one end raised upon trestles, which served the purpose well, except that the length was limited to from 25 feet to 30 feet by the spaces between the hog-chain braces.

The anchors K, shown in Fig. 8, were made by filling with stone a receptacle prepared by taking three pieces of saplings about 4 feet long, and placing them in the base in the form of an equilateral triangle, with sides about 2 feet long, letting the ends of the saplings project. Having bored holes through the intersections and middle points of the sides, these hoop poles were bent and an end of each passed through the holes in the middle points of the sides and the other ends passed through the holes through the opposite intersection of the saplings, and all were fastened in place with wedges. Then wire or small rope was woven on the poles, forming an open basket or receptacle, with meshes small enough to hold stone, the bottom being of rough boards or saplings. These anchors are shown in horizontal, vertical, and isometrical projections in Figs. 8*a*, 8*b*, 8*c*, respectively. They contained from 600 pounds to 1,000 pounds

of stone. They were used throughout the remainder of the year but the manner of attaching was changed from that shown in Fig. 8 to that shown in Fig. 9, by which the weights attached directly to the lower edge of the curtain were replaced by anchors attached by short lines.

Instructions to resume work on the training-wall were received per letter, dated January 9. The scale of operations contemplated, and the form of construction to be used are shown in the following extract from that letter:

"ENGINEER OFFICE, UNITED STATES ARMY,
"*Saint Louis, Mo., January* 9, 1880.

"SIR: As the present mild weather and open river offer a favorable opportunity to complete the closing of the East Channel at Horsetail Bar, which was interrupted by ice in December, you will please make arrangements to resume operations upon a small scale at that point.

* * * * * * *

"The method of construction will, for the present, be the same as that last used, viz, a light curtain of brush, anchored at the bottom and buoyed at the top, and made in lengths as great as practicable.

"By command of Colonel Simpson.

"Very respectfully,

"O. H. ERNST,
"*Captain of Engineers.*

"Mr. D. M. CURRIE,
"*Assistant Engineer.*"

Work was resumed January 12, in accordance with these instructions.

The work which had been done during the fall season had stood the ice that had caused its suspension without sustaining any very serious damages.

A few buoys had been cut from the curtains above dike No. 3, leaving a small gap there, and the buoys had been cut from the open curtains that were placed at the lower end of the gap after December 1. On the remainder of the wall the work was in good condition.

The first work after resumption was to repair the damages to the open curtains by commencing at the up-stream end of the space, which had been filled with them, and refilling that space with curtains made in the same form, except that the barge mentioned in the letter dated December 2, having been completed the length of the curtains, was increased to 96 feet.

After filling this lower space with curtains, another line of them was placed, commencing at the upper end of the gap above dike No. 3, and extending to the lower end of the work, thus doubly covering the lower space with open curtains. Still the water passed through with too great velocity to admit of much deposit. This was remedied, in part, by reducing the spaces between the poles or pieces of brush, and still more by placing another series of poles in the spaces between the poles of the first series, attaching them by wires to the first.

The current still passing through with too great velocity, another form made by weaving brush on poles was used, in accordance with verbal instructions. This form had been designed during the fall season, and was submitted with the report of operations, for the first half year, as a suitable device to be used in deep water, and in lines of hurdles or transverse lines. This form, together with barge and with anchors attached, is shown in perspective in Fig. 9, in which H is curtain, with joint *h*.

The brush, or smaller poles *b*, are woven or wattled on the larger poles *a*. The anchors K are resting upon a platform P, which is hinged to the side of the barge, and is raised by means of chains *n* attached to the shaft S, having a winch at each end, the dogs of which are connected by an iron rod, so that both may be tripped simultaneously by pulling a lever. The joint *h* was used chiefly to gain width for use in deep water, but it also increased flexibility, and that may be the more valuable advantage.

With time, the buoys which had withstood the winter's ice, became unserviceable from various causes; such as being filled under pressure constantly applied during long intervals of time, rotting of lines, blows received from drift-wood and other *débris*, so that it became necessary to place another line of curtains on the whole length of the gap. This was done, commencing at the upper end of the gap April 15, and reaching the lower end June 2, after which a small working party kept the works in repair until the close of the fiscal year. The close curtain shown in Fig. 9 was used in this line, except that the brush having been procured without the construction of that form in view, some of it was too stiff to be used in that way, and to utilize all of the material on hand, the use of the wired curtain was continued, making them close by making the meshes small, and by attaching an extra series of poles.

Of the lines of hurdles shown in rear of the training wall (see map) 19 were built during the fiscal year. They are those below dike No. 2, with the exception of the 3d from that dike, which was built before those between it and the dike, because the

water there was very deep at that time, 52 feet having been found in that vicinity, with the river at 12 feet stage on the Walnut street gauge, Saint Louis.

On resuming work on hurdles September 17, of this fiscal year, this line was found to have been somewhat damaged and was repaired.

The order of construction of the lines for this fiscal year was Nos. 11, 12, 13, 14, 18, 19, completed during the first half of the year, while piles were driven for lines Nos. 15, 16, 17. Lines numbered 11, 12, 13, 14 were broken during the winter on the shoal-water, near the edge of the sand-bar. These were repaired, and the lines below to dike No. 4 were constructed during the second half year.

During the high-water in April, lines Nos. 11 to 23 were broken and were repaired.

The aggregate length of hurdles constructed during the year is 32,000 feet, including the reconstruction of broken portions of lines. The dates at which lines were constructed are shown on the map; the first in order of time showing completion of construction, and the others that of repairs.

Two forms of construction were used. The first was the same as that used during the fiscal year ending June 30, 1879, in which the horizontal rods were wattled directly upon the piles, and the voids were filled with brush placed vertically. Horizontal rods were pushed to the bottom in water 25 feet deep, by means of the hurdling forks. The other form was made by wattling the brush on poles selected from the larger brush. This form was placed by attaching the upper edge to the piles and weighting the lower edge with stone. It was designed and submitted with report of operations for the first half of the fiscal year, as a suitable form of construction, to be used in lieu of hurdles, where the depths of water are so great that horizontal rods cannot be pushed to the bottom. In Figs. 10 and 10*a*, respectively, are shown a horizontal rear view and a cross-section. The advantages claimed for it were that the spaces between the piles could be increased to from 12 to 15 feet, and that in water too deep for piling, the upper edge could be supported by buoys. More important claims may be added, that if attached loosely to the piles, it will sink into any scour that may occur, and that it will exert no buoyant effort to raise the piles out of their places.

In the accompanying profiles, the dotted free-hand lines show the bottom at the dates of the surveys made in the spring of 1879, from March 25 to April 4, and the broken lines show the bottom from surveys of January and March, 1880. The free-hand lines show the bottom at the close of the fiscal year. The planes of low-water, and of 15-foot stage, or the heights to which the horizontal rods of the hurdles were extended, are shown.

The sections were made from soundings obtained from the surveys named, and their lines selected away from the hurdles because the average progress of the silting up is correctly shown there, while the hurdles cause disturbances in their immediate vicinity.

The following statement shows quantities and cost of material expended—

1. Training-wall:		
a. 2,300 linear feet mattress, with curtains, &c., expended constructing and repairing 1,500 feet of wall, in which were used—		
1,431.67 cubic yards stone	$1,030 60	
1,375 cords brush	1,111 92	
Labor, rope, &c	5,352 48	
		$7,495 00
Transportation, equipment, tools, &c		2,759 14
b. 18,700 linear feet curtain, expended constructing 1,000 feet, and repairing 2,500 feet of training-wall, in which were used—		
869.89 cubic yards stone	486 94	
2,384.85 cords brush	1,614 10	
23 piles driven	80 35	
Labor, rope, wire, &c	17,278 65	
		19,460 04
Transportation, equipment, tools, &c		7,448 24
2. Hurdles:		
32,000 linear feet constructed, in which were used—		
100 cubic yards stone	55 00	
4,697.37 cords brush	3,508 83	
3,671 piles driven	12,824 38	
Labor, yarn, rope, &c	12,808 38	
		29,196 59
Transportation, equipment, tools, &c		14,060 95
Engineering, contingencies, &c		4,723 43
Total		85,143 39

All of the forms of construction that were actually used during the year have been described. Still the study of some of the practical difficulties has led to designs which may prove valuable during the future progress of the work here or at other places. They are submitted with that hope, and with the conviction that the permeable system promises success to an extent which entitles it to a full and impartial trial, regardless of the specific form of construction which may, in the end, prove most suitable.

The loss of a section of mattress, with curtains attached, December 1, while it was being placed in deep water, having a strong current crossing the line of the wall at an angle not less than 45 degrees, was certainly not calculated to inspire confidence in the practicability of placing continuous mattresses, with curtains attached, under such conditions. The following solution of that problem secures the practical advantages of continuity without incurring any great risk of loss.

The foundation mattress may be loaded to a greater density than that of water by placing stone or other suitable material between the courses of brush during the process of construction, and before launching make ropes fast to it at any greater distance than the depth of water from the down-stream end, and lay off on the ropes a distance equal to that from the point at which they are made fast to the down-stream end of the mattress. Having completed the section of mats and curtains, launch and sink in the usual way, adding sufficient weight to the top course of brush to secure the whole in place. Commence constructing the next section of mat at the points marked on the ropes attached to the sunken mats so that when the new section is placed it will join that previously placed, securing the advantages due to continuity without encountering the practical difficulties that may be expected in placing continuous mats in strong transverse currents and deep water, with unfavorable weather or variable stages of the river, with its drift-wood or floating ice. In deep, turbulent water, if the curtain were continuous or jointed in all imaginable directions, and under such conditions, it would not be practicable to bring an equal strain upon all the connections with its anchorage or to determine in advance the strain which any of the connections would have to bear at times. The problem would be greatly simplified by breaking the continuity of the curtain in vertical section as shown in Fig. 11, which is an end view of the mattress, with curtains attached.

Other practical difficulties have been encountered, which are chiefly due to the peculiar conditions presented at Horsetail Bar, which may lead to an essential modification of the design to adapt it to these conditions. These conditions arise from the introduction of the c'ear water of the Upper Mississippi River, which maintains itself distinct from that of the muddy Missouri whenever higher stages prevail in that river, rendering it only an intermittent silt-bearer.

No data is available upon which an estimate can be based to determine approximately in what portion of the year such conditions might be expected to exist. It is known, however, that since these works have been in progress such conditions have prevailed the greater portion of the time. The effect of this is to lengthen the time required to secure deposits and to increase the possibilities that works, though suitable for continuous silt-bearing rivers, may be destroyed or injured to such an extent as to render them inefficient before they accomplish their work.

The forms of construction used during the year were designed to accomplish their work in a single season, and were not prepared with a view to have them withstand heavy blocks of ice or drift-wood running continually, nor is it probable that any economical design can be found that will resist these destructive agents indefinitely.

The buoys are the parts of these works most liable to destruction both on account of their exposed position while floating on the surface and their tendency to become water-logged when submerged. It is not practicable to construct a buoy at any economical cost that will withstand heavy ice or drift-wood, nor has any satisfactory form of submerged buoy been discovered, keeping economy of cost in view.

An attempt to decide at this time whether the conditions named habitually exist at Horsetail Bar would be premature. A series of observations conducted through a long period of time would be necessary to obtain the facts, and they, when collected, would decide the question whether a form of construction designed to resist these destructive agents, or which would be less exposed to their action even at a small advance in first cost, would not be more economical in the end.

The subject was studied with a view to prepare to meet an emergency which the long continued clear water at this locality suggested might arise, and the results of that study are submitted with the belief that whether or not it should become desirable to change the form at Horsetail Bar, they are suitable forms for works wherever the conditions named prevail.

In the following designs the buoys have been dispensed with, and the vertical members are made self-supporting by placing successive courses of grillages or open network mats of brush, cane, or other suitable material as shown in cross-section, Fig. 12.

In this section the grillages are shown without any foundation mattress, and this form would be suitable wherever there was no tendency to scour the bottom.

When so used they could be placed by attaching weights in any suitable manner; for instance, several grillages could be bound and a flooring made to hold the weighting material as shown.

In Fig. 13 the grillages are shown attached to a foundation mattress which serves the double purpose of anchorage to the grillages and protection to the bottom. The grillages are shown here bound to each other and to the foundation mattress by wattling the poles of which they are composed on other poles suitably attached to the mattress. This is only intended to show one of the many ways in which the attachment can be made.

In Fig. 14 is shown a permeable screen through which the water may be made to pass in a finely divided state if the grillages should be too open, and the whole is shown as built upon two lines of piles. This form would be suitable wherever the depths are not very great. The distances between piles should be regulated to suit the necessities of each case.

All of the forms composed of grillages are especially suitable for the base of works or that portion below the plane of ordinary low-water.

The material used in constructing any of the forms should be homogeneous, or at least should possess equal lasting qualities in the positions they respectively occupy. With this in view experiments were made with hoop-poles of white oak and hickory woods as fastenings of curtains to their anchorages or joining sections of curtains together. These experiments show conclusively that selected poles, free from knots or other defects, would be suitable means of attaching curtains, feathers, or other devices to their anchorages joining sections of said devices, and that pins or "grubs" of the same woods would be suitable means of binding mattresses or open grillages together.

Two other important considerations should receive attention in designing works to improve silt-bearing rivers, by securing a deposit of a portion of their sediment. These are the degree of permeability and the height that should be given works in order to secure the best results. The degree of permeability which promises the best result is that which permits the water to pass through with such small velocity that vortices having transporting energy will not be formed, and at the same time sufficient to keep up the circulation and convey away the water which has deposited its load of sediment. This degree of permeability is indicated by an oily or glassy appearance of the surface flowing smoothly without boils or whirls. The height that would be most effective would be above the stages from which deposits are expected to be obtained, for while the works are submerged there is a stratum of water above them having a free flow while that below is obstructed; in other words a greater velocity superposed upon a less, which would tend to form vortices, and, if the difference between the two velocities is great, vortices may be formed having energy sufficient to scour in the immediate vicinity. This effect may be seen well defined in a thin sheet of water pouring over a weir. It is difficult to secure deposits immediately behind solid works which are submerged only at mean and high stages on account of the scour produced by vortices generated by the water pouring over them. The effect of permeable works differs from that of solid in degree only. If the velocity could be checked so that on entering the lower pool it would not differ greatly from that of the pool, vortices having scouring energy would not be generated and deposits would be secured close to the work as well as further away. In permeable works this is done while the works are not submerged.

Willows were planted on the bar in rear of the training-wall, in compliance with instructions per letter, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY.
"*Saint Louis, Mo., February 23*, 1880.

"SIR: With a view to ascertaining the best season and the best level at which to plant willow cuttings upon the soil reclaimed from the river, you will please make some experimental plantations at the first of each month during the coming season, beginning on the 1st of March.

"The cuttings used for the purpose will be fresh cuttings, 3 feet long and of any size, from ½ to 4 inches in diameter, the growth of last year, however, being considered the best. They will be sharpened at one end and thrust into the ground to a depth of 12 to 18 inches. They will be planted in groups of 10 each, in quincunx order, the distance between them being 3 feet.

"A group will be planted at the level 14 feet above low-water, one at 15 feet above low-water, one at 16 feet, &c., up to 25 feet, making twelve groups each month. These levels are to be ascertained instrumentally.

"The groups for each month will be arranged upon a straight line, at a sufficient distance from the other plantings to prevent any difficulty in identifying them. The positions and dates of the plantings will be recorded upon a sketch of the ground.

"You will please keep such notes upon these plantations as will enable you to make a full report upon the subject at the end of the season.

"By command of Colonel Simpson.

"Very respectfully,

"O. H. ERNST,
"*Captain of Engineers.*

"Mr. D. M. CURRIE,
"*Assistant Engineer.*"

The groups were planted as nearly in accordance with the instructions, both in time and in order, as was practical. They were delayed on account of the rush of other matters incident to the work about the first of each month.

The contours of the ground rendered it impracticable to maintain strictly all the conditions required by the foregoing instructions—groups of 10 at each foot of elevation, in quincunx order and in straight lines. The groups of 10 could be planted in quincunx order only at elevations 17 and 18 feet above low-water, these being the elevations of the crest of the bar. The higher elevations were found only on the steep slope of the bank at the main shore, and the lower where the bar slopes rapidly.

After careful examination, a location was finally selected between hurdles, lines numbered 11 and 12, and a line was fixed by stakes 40 feet north of and parallel with line No. 12, as the center line of the groups planted March 9. These were small cuttings in groups of 10 at each foot of elevation, from 14 to 25 feet above low-water. Those planted at elevations from 18 to 25 feet were on the slope of the main shore, and extended 50 feet from a large stake set near the edge of the bank. The other groups were planted on the bar between distances 500 and 560 feet from the stake mentioned. With the exceptions named, the cuttings in each group were planted on the same elevation, instrumentally determined.

The next groups were planted April 9, on a line 12 feet north of and parallel with those planted in March, and in elevation at each foot between 15 and 25 feet above low-water, the plane of 14 feet being submerged at that time. Three sets of groups were planted at this time, one of small cuttings thrust into the ground, one of small cuttings buried in trenches 15 inches deep, with the tops turned up, and one of pieces 3 feet long by from 3 to 4 inches in diameter, freshly cut and set in holes 18 inches deep bored with a post-auger. These groups cover a space about 36 feet wide.

On the 11th of May three sets of groups were planted as in April, between elevations 18 and 25 feet. These are located north of the April plantings.

The next and last set of groups were planted June 8, adjoining those planted in May on the north and at each foot of elevation between 19 and 25 feet.

Of these plantations all those planted in March lived, while of those planted in April only the larger pieces and the cuttings planted below 18 feet elevation took root. The May and June plantations all dried except a few of the larger pieces. When planted, after the rise of the sap the larger pieces seem to prosper better for a time than the small cuttings, but saplings from which these pieces were obtained would live for some time after being cut if only protected from the direct rays of the sun. Nothing can be positively asserted in relation to their prospects for future growth.

On the map of Horsetail Bar made under your direction to show progress of work from surveys made by Mr. Preston C. F. West, assistant engineer, and to which reference has been frequent in this report, the locations of these groups of willows may be seen.

Receivers of material, Mr. William S. Mitchell and Mr. C. D. Lamb, who were respectively connected with the work during the first and second halves of the fiscal year are entitled to more than a passing notice for faithful and intelligent service rendered in keeping records of labor and material expended, and assisting in the details of the administration of the work.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Capt. O. H. ERNST,
Corps of Engineers, U. S. A.

B

REPORT OF MR. CHARLES S. TRUE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *January* 12, 1880.

GENERAL: The following report of work done at Cairo Protection and Kaskaskia Protection during the half year from July 1, to December 31, 1879, is respectfully submitted:

CAIRO PROTECTION.

Work in progress at Cairo Protection on the 30th day of June, 1879, was continued till October 14, 1879. The revetment of the bank was extended upstream 2,900 feet

above previous works by sinking rafts of brush out to deep water and covering the sloping bank between these rafts and the steep top banks with a thin layer of stone. The brush rafts were mostly 70 feet wide, and the protection of stone inside the rafts was irregular in width according to the shape of the bank, but would average about 75 feet. The height to which the revetment was carried was about to a 20-foot stage of water in the Mississippi River when the Ohio River is low, or a 25-foot stage when the Ohio has a good navigable depth. The protection begun during the first half year of 1879 was raised to a similar height, and some additions were made to the work of former years to repair weak places. Some work was done to protect the bank between the spur-dikes placed by the Cairo Land Company.

About 1,000 cubic yards of stone were taken from the outer end of the upstream spur, yet remaining, and placed on the bank above and between the spurs. Of this stone, 291.70 cubic yards were moved on a barge, and the remainder by wheelbarrows.

A brush raft was sunk just below the upper spur, and a curtain of brush was stretched between the 3d and 4th spurs to break the current of the eddy and induce deposit. This curtain was secured at the surface of the water by a boom of dry logs, and the free edge of the curtain was weighted with stone to carry it to the bottom.

The quantities of material used on the protection during the half year, including 314.20 cords of brush on barges, July 1, but not including stone taken from the spur-dikes, were: on continuation of protection begun in 1879, 1,819.10 cords brush, 13,108 cubic yards stone, and on repairs of revetment of former years, 116.40 cords brush, 540.90 cubic yards stone.

The brush used was cut by hired labor on tow-heads in the Mississippi River, and the stone was quarried by hired labor at leased quarries at Gray's Point, Mo.

The transportation of material was by barges and tow-boat, owned and operated by the government.

The new protection placed during the year 1879 covered a front of 7,600 feet. This was rather light, and will need additions and repairs when the river shows its weak places. The revetment will need to be raised some when the top bank is sloped enough to carry stone with safety. The total length of banks at Cairo Protection, on which work has been done, including the stone placed by the Cairo Land Company, is 14,200 feet. The river is attacking the banks below this work, and the protection may need to be extended some in both directions. The condition of the work when last examined was good.

Two bad piles of stone, formed by the river washing the bank back from the two upstream spur-dikes placed by the Cairo Land Company, endanger navigation during low-water. In the early part of October the water over these stones was but two feet deep. At that time the width of channel between the upstream pile and the Illinois shore was 545 feet, and between the downstream pile and the shore 336 feet. A new shore line was run and stakes set each 100 feet to refer work to. The line begins at a stone set 700 feet downstream, from the lower end of the revetment, and runs upstream. It was connected with points marked △ 12 and △ 14, of Lieutenant Lockwood's survey, and with the street system of Cairo. A section of the Mississippi River, taken September 25, 520 feet up stream from O point of shore line, showed the river at that place to be but 743 feet in width. Nearer the mouth of the Ohio, and just below the incline of the C. A. and T. Railroad, was a narrower part of the river, but the width was not measured. The whole volume of the Mississippi passed in one channel at both points. Changes in the slope of the Mississippi River, near the mouth of the Ohio, were shown by levels taken September 6 and September 25. The Ohio at the United States gauge in front of Cairo fell 13.5 feet during the time, while the Mississippi back of Cairo, at the line of Twenty-eighth street, fell but 8.93 feet—a difference of 4.57 feet.

The shoalest water during the season between Cape Girardeau and Cairo was near Power's Island, where the river was divided into four channels by Santa Fé Island, Beaver Dam, Towhead and Power's Island. At one time in September the greatest navigable depth was 4¼ feet.

To illustrate some details of work done during the half year, I will state that the rafts sunk along the middle of Cairo Bend, when out of deep water, left a wide slope to be covered with stone; for this reason the width of the rafts was increased to 70 feet. The upstream part of the revetment placed has rafts of this width for a length of 2,125 feet. The quantities of material placed on this part of the bank were 1,570.90 cords brush, 6,344.70 cubic yards stone, which gives about 0.74 cords brush and 2.99 cubic yards stone per linear foot of bank.

On the bank next below this upper section 2,351.30 cords brush, 15,931.80 cubic yards stone, were placed in 5,475 linear feet of revetment, which gives about 0.43 cords brush and 2.91 cubic yards stone per linear foot of bank. Acting on some ideas partly gained from a conversation early in July with Principal Civil Assistant Engineer R. E. McMath, and from whom I understood such a course would be approved, I used earth for the chief weight for sinking rafts. To hold the earth the rafts had to be made closer than large willows such as we had been using would make them;

for this reason the middle course of the new rafts was made of weeds and small willows. The rafts were loaded as nearly uniformly as practicable with earth taken from the bank; then a few stone were placed on them to complete the sinking. The experiment was tried on some rafts of loading entirely with earth. When the rafts were a few feet below the water's surface the strong current over them washed much of the earth from them, so that the expense of extra labor required to completely sink the rafts with earth was greater than the cost of stone necessary for the final weight to be used after the raft passed below the surface would have been. A small quantity of stone was put on each raft after it was sunk, to help keep it in position and to make the connection of the raft with the riprap certain.

The method used for sinking brush rafts with earth can be employed advantageously when the current is not more than 2 miles per hour, but in a strong current it will be economical to put the earth required for the last weights to sink the brush in some envelope to give it the necessary firmness to resist the washing of the water.

In localities where, for any reason, stone cannot be readily obtained, earth, sand, or mud can be used as weights for sinking any other material, or for anchors to hold any structure or device used for the improvement of the river. I think, however, that on the Mississippi River above Cairo, when brush is to be sunk in a deep, strong current, it will be, generally, more economical to use stone for weights. The use of stone rather than earth, as a sinking material, will be economical in some cases in comparatively slack water which is readily accessible to steamboats and barges; as brush to be sunk by stone can be used in thin open mats while, when earth is to be used it must be put in some envelope, or the mats must be thick and close enough to hold a large per cent. of the earth or sediment brought in contact with it.

Such a thing as a simple, direct current does not exist in a great river, and any obstruction placed in the current adds new complications to the direction of the forces of the water. In sinking rafts or mats it is important that the anchorage be located so as to help carry the rafts to the bottom, and at the same time prevent their being twisted by the currents. On our shore work a combination of surface and bottom anchorage gave the best results as to direction of strains.

The surface anchorage used was a number of lines from barges moored upstream from the raft, and side lines from the shore to prevent the raft swinging out too far.

The bottom anchorage was by lines from the head of the raft to anchors placed in the river above the raft. Two such lines were usually sufficient.

At Kaskaskia, the rafts already sunk were used for the bottom anchorage with good success. This was suggested by the method used by Assistant Engineer D. M. Currie for anchoring hinged mats and curtains at Horse-tail Bar. Bottom anchor lines had little effect till the raft began to sink when they were brought into use by slacking the surface lines so as to keep an even but not severe strain on them. The bottom lines were gauged in length to regulate the connection between the rafts sunk, and some of the lines were arranged with an outward strain to prevent the raft swinging towards the shore while sinking. With long rafts additional lines towards the middle and foot of the rafts to help hold and guide them were found beneficial. Long rafts are not always economical where the current is strong. More time is required for their construction, and they are more liable to accidents from drift-wood, storms, boats, and other causes, than short rafts. Long rafts are harder to hold than short ones, and from the tendency to neglect the even distribution of loading material, and the greater difficulty of rapid and even application of final sinking weights, they are more liable to be badly sunk.

On shore work where the inner edges of rafts were sunk in water varying from 10 to 25 feet in depth, and the outer edges in depths of 25 to 43 feet, the rafts being weighted with stone from barges 165 feet long, the most satisfactory length for rafts was from 175 to 225 feet. The most usual length was about 200 feet.

Shore or floating ways to build brush protections on are economical in many places, as the brush can be formed into thin mats or screens on them, while rafted brush must have thickness and buoyancy enough to carry workmen.

KASKASKIA PROTECTION.

Work at protecting Kaskaskia Bend was carried on during the first nineteen days of July. The work done consisted of making 340 linear feet of brush rafts and sinking them at the foot of the bank; and of placing stone riprap on the slope of the bank from a height of 22 to 25 feet above low-water downward below low water level. The protection was extended 1,100 feet beyond former work.

Work was suspended from July 19 to September 22, when it was resumed.

The work done in September, October and November consisted of making brush rafts, 50 feet in width, and sinking them at the foot of the slope outside of the revetment on the bank. The outer edges of the rafts were sunk in water varying from 25 feet in depth near the head of the bend to 43 feet about 2,000 feet farther down stream, when the stage of water was from 8 to 10 feet on the Saint Louis gauge. The length

of bank along which rafts were sunk was 3,305 feet. A length of 2,915 feet was at the upstream end of the protection to revet the foot of the bank in front of from station 1+75 to 30+90 of the new shore line.

Just below the work of 1878 and in front of station 34+50 to 36+90 of new shore line, 240 feet of raft was sunk close to the bank, to protect the bottom of the eddy in the cove and stop a cut in the bank below. At the lower end of all stone work a raft 150 feet long was sunk to stop cutting of the eddy below the stone. This raft was close to the bank and in front of station 60 to 61+50 of new shore line.

Earth was used to help sink some of the rafts. Stone used for sinking rafts was taken from the revetment already on the bank. Two barge loads of new stone were added to the protection at the upstream end of the bend.

The quantities of new material placed on the protection were as follows: In July 320.86 cords brush and 7,350.93 cubic yards stone; and in September, October, and November 2,100.20 cords brush and 519.60 cubic yards stone.

The changes made in position of material already on the bank consisted of picking up 1,474 cubic yards stone where the revetment above water was heaviest, loading it on barges, and unloading it on the slope of the bank, where the former protection had sunk below the surface of the water.

The total length of bank on which work has been done at Kaskaskia Bend is 5,975 feet. The up-stream part of the bend for the length of 2,500 feet is partially protected to a height of 10 feet above low-water, and the bank down-stream from this for a length of 3,325 feet, as reported by Mr. McDonald, to a height of 22 to 25 feet above low-water. The downstream 150 feet has a single brush raft 50 feet in width reaching up to low-water level.

The condition of the work at Kaskaskia cannot be called good.

The bank is too steep to carry stone safely, which gives the stone a greater tendency to slide forward into deep water than to settle down vertically. The bank slides some at the base along the up-stream end of the work, and washes above the stone when the water is above the revetment. The bank needs additional protection and some grading to give it a proper slope. As the sand washes too fast to trust the grading to the river, the most convenient way to do that work will probably be the one proposed by Captain Ernst, to wash the bank down by large pumps.

After the bank is graded the inclined surface can be protected for a time by thin brush-mats fastened to the ground beneath the mats.

Some additional stone will be useful to make a good connection between stone already on the bank and any new protection that may be placed above it. There is now quite a body of stone at the foot of the bank, along the up-stream part of the bend, and if the bank above water is graded flat enough, say to 25° or 30° rise from a horizontal plane, stone will probably lie on the bank and can be used to form the upper protection, if deemed advisable to use it.

The auxiliary brush-mats you have adopted for the foot of the slope, beneath the water, are required for an additional length of 3,060 feet from in front of station 30 + 90 of shore line down stream to the lower end of the protection.

The protection will need be extended down stream a few hundred feet to prevent a wash across a low neck of land to the Kaskaskia River.

The shore line run in 1878 was partly washed into the river. A new line was run and stakes set 100 feet apart to refer work to.

The up-stream, or O, end of the line is at a set stone at the head of the bend, and 175 feet up-stream from the present revetment. A stone set at station 25 is the same as station 18 of line of 1878. Stones were set at points of survey of March, 1876, at point near bend of Kaskaskia River, 2 feet from forked pecan tree, and at point near Strue's house, 6 feet from locust.

CHARLES S. TRUE,
Assistant Engineer.

General J. H. SIMPSON,
Corps of Engineers, U. S. A.

P 2.

ICE HARBOR AT SAINT LOUIS, MISSOURI.

The river and harbor act of June 14, 1880, contains the following items, viz:

For ice harbor at Saint Louis, Mo., fifty thousand dollars: *Provided*, That no part of this sum shall be expended until a Board of Engineers shall have been convened and determined upon a plan for the construction of the work.

The most suitable place for such a harbor in this vicinity is the chute east of Arsenal Island, or Cahokia Chute.

This was formerly the main channel of the Mississippi, but was closed to navigation by a low dam constructed in 1877–'78. It is that portion of the chute below the dam which it is proposed to convert into an ice harbor.

There has been no opportunity, as yet, to determine upon a completed project, but enough is known of the locality and the necessities of the case to justify the assertion that the sum asked for, $100,000, is less than will be required to complete the work.

Money statement.

Amount appropriated by act approved June 14, 1880	$50,000 00
July 1, 1880, amount available	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	100,000 00

P 3.

IMPROVEMENT OF MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU AND MINTON'S POINT, MISSOURI.

The river and harbor act of June 14, 1880, contains an item appropriating $20,000 for "improving Mississippi River at or near Cape Girardeau and Minton's Point, Missouri."

A survey of the locality will be undertaken as soon as the river falls to a suitable stage, with a view to preparing a plan of the works required and an estimate of their cost. Sufficient is known of the case to justify asking for $50,000 for next year, to continue the improvement. The sum now available is not sufficient to exert any beneficial effect upon the landing at Cape Girardeau except by dredging. Dredging in this part of the Mississippi is an expensive way of procuring an inefficient and temporary relief, and cannot be recommended. It is supposed that permanent relief is what is desired, and it is proposed to employ the money available in beginning the works necessary for that purpose with the expectation that the additional funds required will be provided in the future.

Money statement.

Amount appropriated by act approved June 14, 1880	$20,000
July 1, 1880, amount available	20,000
Amount that can be profitably expended in fiscal year ending June 30, 1882	50,000

P 4.

IMPROVEMENT OF OSAGE RIVER IN MISSOURI AND KANSAS.

The river and harbor act of March 3, 1879, appropriated $20,000 for this work, which was employed in continuing the method of improvement followed during previous years. The latter consists of contracting the width of the river at certain shoals by means of cross-dams and training-walls, dredging the channel by means of teams and scrapers, and the removal of rocks and snags from the channel and of leaning timber from the banks, the object being to obtain a 2-foot channel at the lowest

stages of the river. All the works were carried on by hired labor and purchase of material in open market.

MOORE'S FLATS.

(40 miles from the mouth.)

Work was begun at Moore's Flats on the 10th of July. The dam built last was strengthened by being loaded with stone, and the training wall was repaired and extended upstream a distance of 200 feet. Sixteen snags were removed from the channel at the lower end of the shoal. Later in the season the training wall was extended 900 feet farther upstream, contracting the channel to a width of 80 feet.

The total length of the training wall is now 1,750 feet, of which 1,100 feet was built this year. It was constructed of riprap on a brush foundation.

The locality is shown in the adjoining sketch, in which the works are indicated by the heavy full lines. The upstream portion, from A to B, was built this year.

HOSKINS', OR LITTLE TAVERN SHOALS.

(43¾ miles from the mouth.)

This locality is shown in the adjoining sketch. The river was divided into three chutes by Hoskins' Island, and a smaller island to the westward. The chute between the latter island and the main shore had been closed in former years by an old State dam, extending from *a* to *b*. It was decided to extend this dam across the small island, and then changing its direction to push it across the stream and connect it with a training wall, *c d*, thus contracting the channel to a width of 89 feet (see sketch). A dam 743 feet long and a training wall 430 feet long were constructed of riprap on a brush foundation. Forty snags were removed from the channel.

REYNOLDS' SHOAL.

(45½ miles from the mouth.)

The work at this shoal consisted of the removal by blasting of some rocks from the channel, amounting in all to about 300 cubic yards; of cutting from the bank eighty-eight overhanging trees, and of removing forty snags from the channel. The dam at Hoskins' Shoal, 2 miles below this, serves to increase the depth of water on this shoal, so that there is now a depth of 2 feet or more at the lowest stages.

KIRKMAN'S SHOAL.

(47¾ miles from the mouth.)

This locality is shown upon the adjoining sketch. Several dikes, *a b*, *c d*, *e f*, had been built in former years by the State of Missouri, but the shoal remained one of the worst upon this portion of the river. The plan adopted for improving it was to build a dam, *g h*, from the right bank out into the river, a distance of 250 feet, connecting it with a training wall, *i k*, 1,320 feet long. The peculiar shape of the opposite bank made it necessary to supplement the latter by a second training wall, *f l*, 630 feet long.

For this wall the State dam was used as a foundation for a length of 60 feet. All these works were built of riprap upon a foundation of brush. At the foot of the artificial chute thus formed a channel was dredged out, the quantity of material removed being 840 cubic yards.

DEVIL'S ELBOW.

(49 miles from the mouth.)

This was a narrow chute which was difficult to navigate on account of the rapidity of the current and the crookedness of the channel, which was partly obstructed by snags and overhanging trees. Fourteen snags were taken from the channel and eighty-five trees cut from the banks. The dam at Kirkman's Shoal, 1¼ miles below, has backed the water up to this shoal, deepening it somewhat and diminishing the velocity of the current.

PACK'S SHOAL.

(50 miles from the mouth.)

The work at this place consisted of dredging a channel 350 feet long and 75 feet wide, involving the removal of 455 cubic yards of gravel.

The work at Kirkman's and Pack's Shoals was finished October 14.

There being some repairs and extensions required upon the works previously constructed which would occupy the force during the remainder of the working season, it was not deemed advisable to begin any work above those points. The force was accordingly ordered back to Moore's Flats, where the training wall was extended as above reported. On the way down an obstruction to navigation was found to exist in

CLARK'S ISLAND SHOAL.

(41¾ miles from the mouth.)

A channel 80 feet wide and 400 feet long was dredged through this shoal, involving the removal of 782 cubic yards of gravel.

BURD'S SHOAL.

(21¾ miles from the mouth.)

A steamboat had grounded at the head of this shoal in August, and in getting her off the gravel had become so flattened out as to leave but about 6 inches depth of water in the channel. Temporary relief was given at the time by dredging. It was decided to diminish the chances of accidents of that kind by further contracting the width of the chute. The locality is shown in the adjoining sketch.

The full heavy lines *a b c* show the old work. A dam, *d e*, 195 feet long, was run out from the left bank and connected with a training wall, *g h*, parallel to the old training wall, and 90 feet from it.

The new training wall had been built to a length of 450 feet when the approach of winter rendered it imprudent to keep the equipment any longer so far from its winter quarters, and the work was accordingly suspended. It is proposed to extend it about 600 feet during the coming year.

These works were built of riprap upon a foundation of brush.

During the month of January the recently constructed dam was broken

at its shore end, and a considerable current passed through forming a bar at the foot of the chute, and endangering the dam. A force was set at work as soon as practicable to repair the damage. The break, 82 feet in length, was repaired and the bank was graded and revetted above and below the dam for a length of 206 feet, the whole being completed on the 9th of February.

SHIPLEY'S SHOAL.

(9 miles from the mouth.)

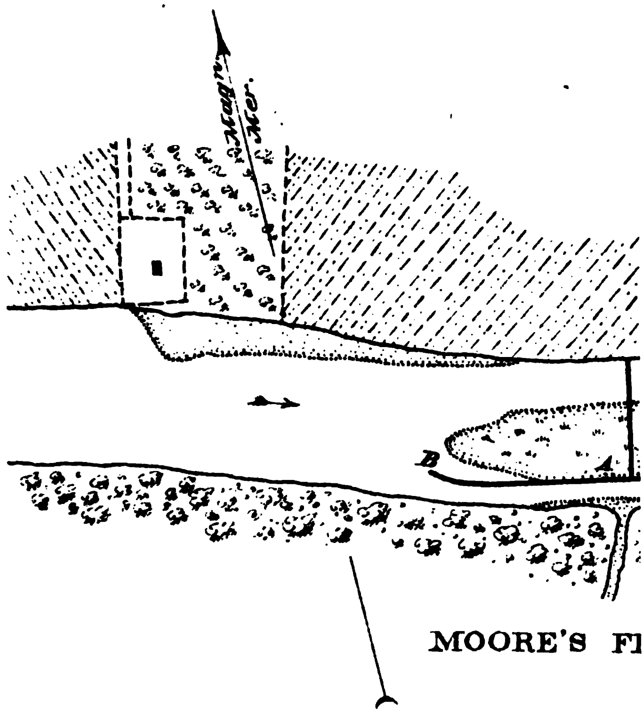
A further extension of the training wall at this shoal had become necessary. The improvement of this locality is more temporary than at the other shoals because of the backwater from the Missouri River. This meeting the barrier formed by Shipley's Shoal drops the sediment which it carries and builds up a new bar at the foot of the chute with much more rapidity that the Osage itself could do with its gravel. The remedy for this has been for the last two seasons to extend the training wall downstream until the foot of it reached a point where the water was from 3 to 5 feet in depth. During a part of the months of November and December the wall was extended a length of 1,050 feet. On the 18th of December the weather became very cold, causing ice to form, and it was not considered safe to keep the steamer and barges any longer at work. During the winter a break 82 feet long and from 9 to 15 deep occurred in the cross-dam at the shore end. Work was resumed on the 9th of March. The breach in the dam was repaired, the bank was revetted for a length of 50 feet above and 120 feet below the dam, and some weak portions of the dam were strengthened. Work upon the training wall was then resumed and continued until the 10th of April, when the river became so high that it was necessary to again suspend operations. The wall had been extended 375 feet, making a total extension for the year of 1,425 feet. It has now reached a long flat bar known as Brennecke's Shoal. It is proposed to extend it across this shoal during the coming year, which will require an addition of 2,600 feet. This will carry it into water about 8 feet deep.

The adjoining sketch shows the position of the works already executed and that of the proposed extension, the latter being indicated by a broken and dotted line. There is now a 2-foot channel at the lowest stage from the mouth of the river to the foot of Berry's Shoal, a distance of 51 miles, with the exception of about 2,600 feet at Shipley's Shoal and 600 feet at Burd's Shoal. Of this distance, 40 miles from the mouth, or as high up as Moore's Flats, had been the subject of improvement in previous years.

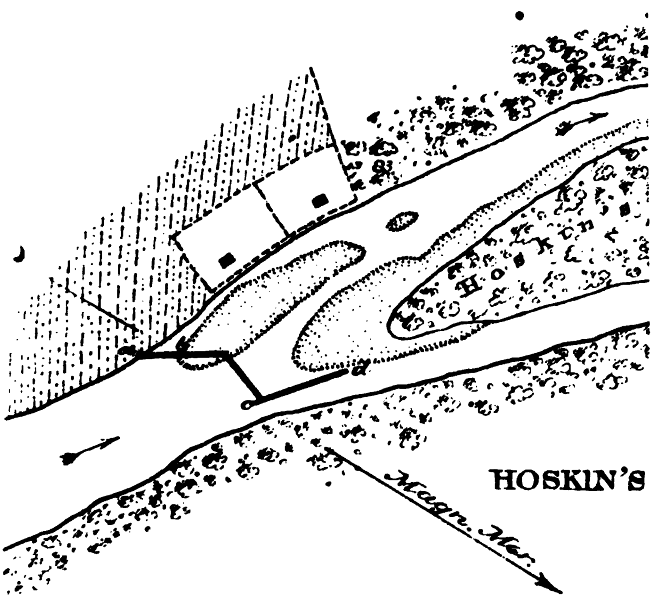
The result of the year's work is, therefore, 11 miles of river opened to low-water navigation, and the maintenance of the previously obtained channel for a distance of 40 miles with the exceptions above given. It may be necessary to build dams and training walls at some of the shoals where as yet only dredging has been done, but with these, since the Osage River is a stream of perfectly clear water flowing over a bed of gravel, with substantial banks, I see no reason why the beneficial results will not be reasonably permanent.

APPROPRIATION OF JUNE 14, 1880.

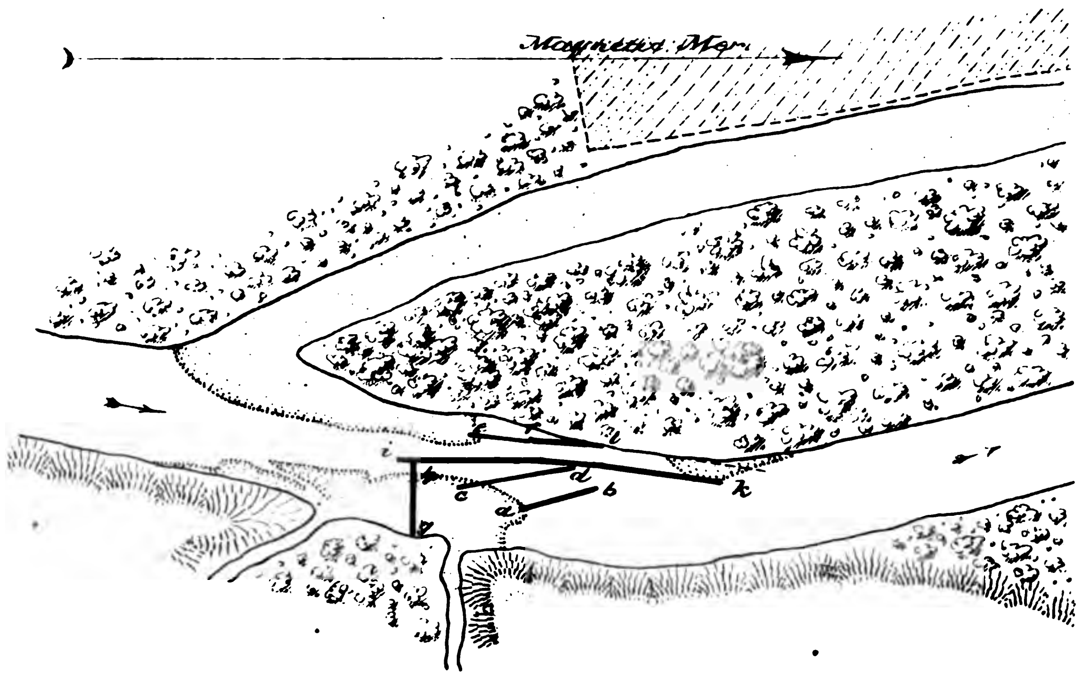
The river and harbor act of June 14, 1880, appropriates $30,000 for the continuation of this improvement. Of this sum $5,200 have been



MOORE'S F

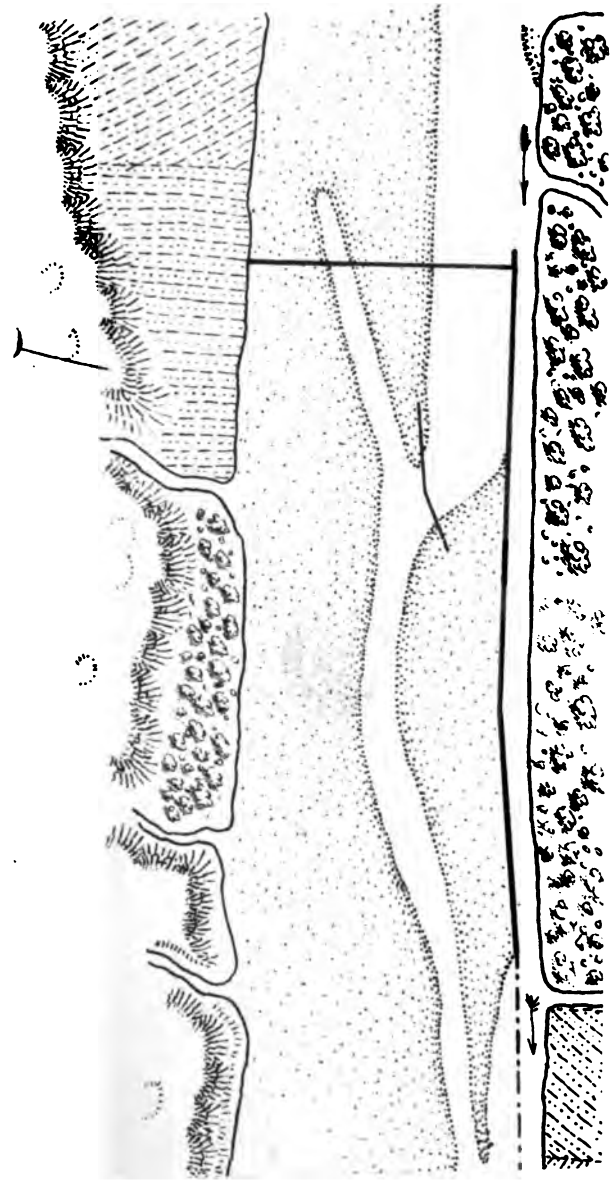


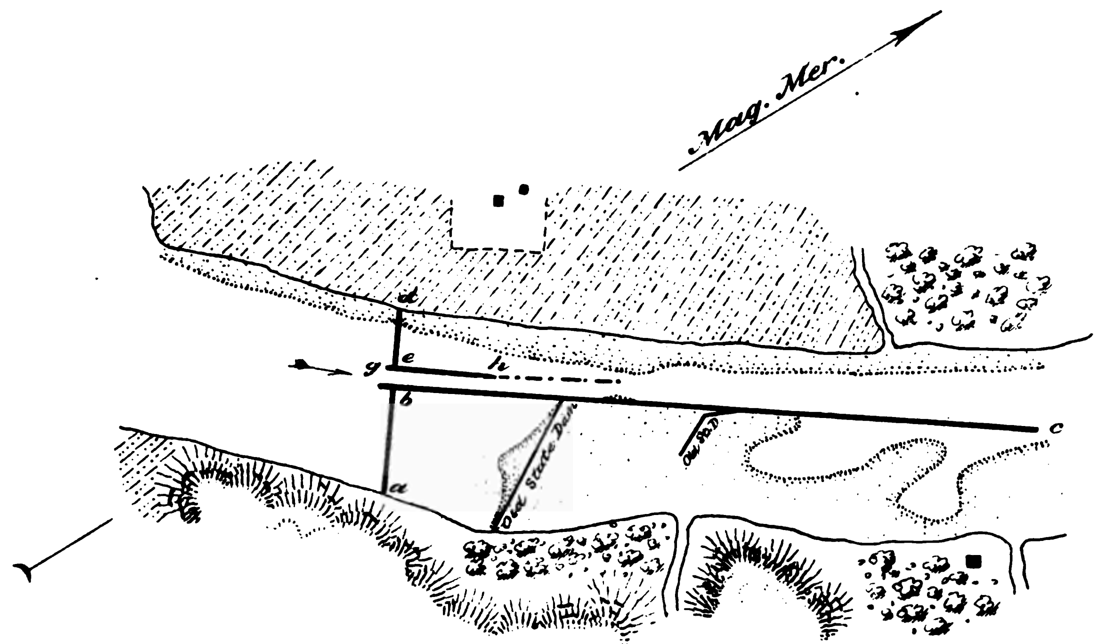
HOSKIN'S



KIRKMAN'S SHOAL, OSAGE RIVER

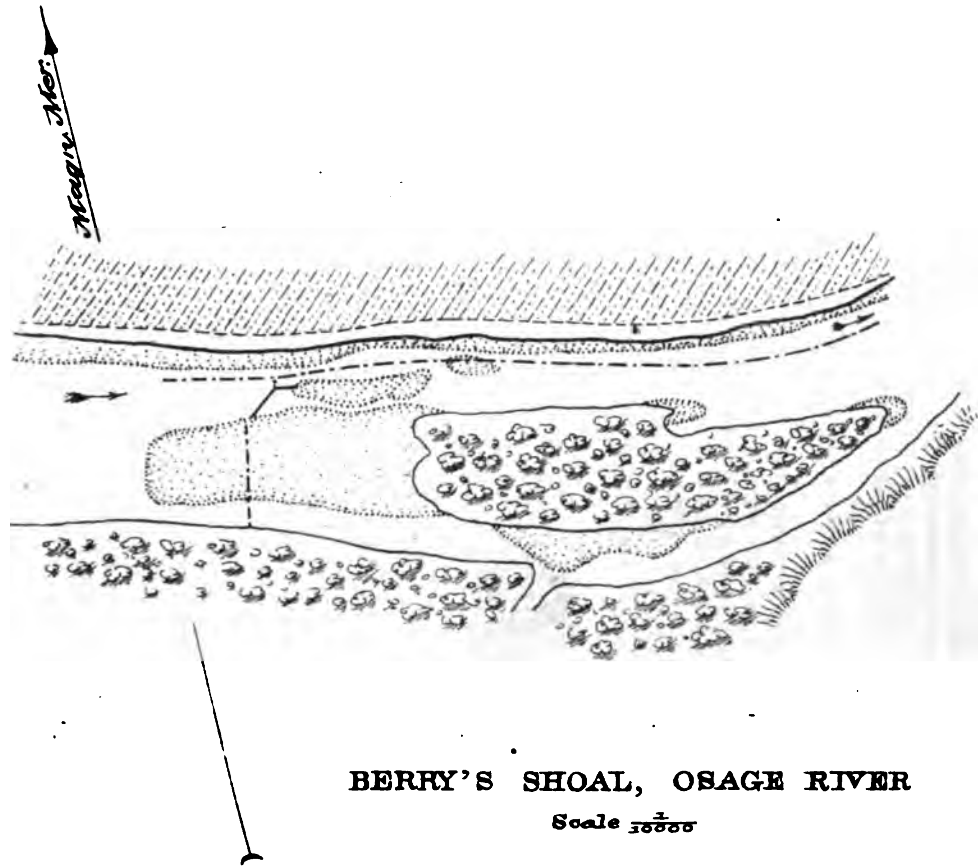
Scale $\frac{1}{10000}$





BURD'S SHOAL, OSAGE RIVER

Scale $\frac{1}{13000}$



BERRY'S SHOAL, OSAGE RIVER

Scale $\frac{1}{10000}$

allotted to the extension of the training wall at Shipley's Shoal and $1,200 to similar work at Burd's Shoal. At Berry's Shoal (51½ miles from the mouth) a depth of only 6 inches is sometimes found at low-water. It is proposed to contract the river to a width of 80 feet, by means of a dam and training wall like those used at the other shoals, with a view to securing a depth of 2 feet at the lowest stage. The adjoining sketch shows the location of the proposed works. The sum of $7,500 has been allotted to this work.

There are four shoals, viz, Music's, Saline, Burdsong's, and Town's, upon which the work will consist principally in removing snags from the channel, cutting leaning timber from the banks, and in one or two places scraping gravel. The sum of $3,800 has been allotted to the works at these four shoals.

When the works above mentioned shall have been completed, there will exist at low-water a channel of 2 feet in depth from Tuscumbia to the mouth, a distance of 60 miles. Above Tuscumbia as far as the mouth of Rainey Creek, a distance of 90 miles, there has been no survey made. The sum of $2,500 has been allotted for the purpose of surveying that portion of the river, with a view to preparing plans for its improvement. There will then be a continuous map from Ottawa, Kans., to the mouth. The balance of the funds available is held in reserve for works above Tuscumbia, after the completion of the survey.

RECAPITULATION.

Shipley's Shoal	$5,200
Burd's Shoal	1,200
Berry Shoal	7,500
Music's, Saline, Burdsong's, and Town's Shoals	3,800
Survey above Tuscumbia	2,500
Reserved for works above Tuscumbia	9,800
Total	30,000

It is proposed to carry on the greater part of these works by contract. That system can be applied to the works at Shipley's, Burd's, and Berry's Shoals. In the case of those shoals where the work will consist of removing snags and overhanging trees and scraping gravel—viz, Music's, Saline, Burdsong's, and Town's—the indefinite amount of the work renders it impracticable to prepare accurate specifications in advance. The work at these shoals will be carried on by hired labor.

ESTIMATE FOR YEAR ENDING JUNE 30, 1882.

The sum of $50,000 can be expended to advantage during the year ending June 30, 1882. It is intended to employ it in removing obstructions to navigation above Tuscumbia, the exact position of which cannot be given until after the completion of the survey to be undertaken this year. The intention is to create a continuously good navigation ascending the river each year as far as the means available will permit. There is no definite project for the improvement, and it is therefore impracticable to fill out that part of the money statement which gives the amount required to complete.

Money statement.

July 1, 1879, amount available	$20,791 10	
Amount received for fuel sold to officers	124 50	
Amount appropriated by act approved June 14, 1880	30,000 00	
		$50,915 60

July 1, 1880, amount expended during fiscal year:		
By Col. J. H. Simpson, Corps of Engineers	$17,815 21	
By Capt. O. H. Ernst, Corps of Engineers	2,305 40	
		$20,120 61
July 1, 1880, amount available		30,794 99
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 00

P 5.

SURVEY AND ESTIMATE OF THE DAMAGES TO RIPARIAN OWNERS IN FRONT OF THE TOWN OF VENICE, ILL., BY REASON OF GOVERNMENT IMPROVEMENTS MADE OR TO BE MADE AT OR NEAR SAID TOWN.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., April 10, 1878.

GENERAL: According to the instructions contained in your letter dated May 1, 1877, requiring a survey and estimate to be made "of the damages, if any, done or to be done to riparian owners of lands, and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made, or to be made, at or near said town of Venice," a survey was made by my assistant, Mr. William Popp, in September and October, 1877.

The accompanying map of this survey, on a scale of 1 inch to 200 feet, embraces the towns of Venice and Brooklyn, the Mississippi River from Bischoff's dike to head of Bloody Island, and the river front of the city of Saint Louis from Ferry to Florida streets. The towns of Brooklyn and Venice are laid down on the authority of the public records of Saint Clair and Madison Counties. The subdivision of the lands of the Madison County Ferry Company is copied from a map or plan loaned for the purpose by the ferry company. The location of the old works, shown in blue and green, is not absolute, being transferred from the old maps, and depends upon the accuracy of the surveys, and plotting of those maps. The full blue lines are taken from the map made by Lieut. R. E. Lee, in 1839, and the broken blue lines are from a map compiled by Henry Kayser, City Engineer of Saint Louis, in 1849. The works shown in green are taken from a map made from a survey in 1861, and represent the location and then condition of the early works. Red shore lines and figures are taken from the survey made in 1870 by Capt. Charles J. Allen, Corps of Engineers, and the black lines and figures represent the survey of 1877. Actual soundings are given in both cases, the stage being practically the same, + 7'.3 at time of survey in 1870, and + 7'.2 in 1877.

The examination of the question of damages necessarily involves a search of the records to ascertain what had been done and the purpose of the works, also any acts of the parties interested which would bear upon the question presented. This examination was made by my assistant, Robert E. McMath, and the result is embodied in a report upon the matter dated March 20, 1878, a copy of which is forwarded herewith. Mr. McMath arrives at the following facts bearing directly upon the question of damages:

1. Damages done previous to 1872 were compensated for by a payment made in 1841.

2. Said payment covered also damage to be done by completion of the plans then contemplated.

3. The party to whom payment was made is the same as the corporation now owning the entire Venice front.

4. The legislature of Illinois in 1849 recognized that the ferry company had relinquished their rights upon this front, for it recovered to the ferry company the right to use a certain dike to be built upon the ground owned by the ferry.

5. In recovering this right the legislature imposed certain conditions upon the ferry which have not been fulfilled.

6. The works built by the United States in 1873 do not materially differ from those provided by the legislature in the interest of the riparian owners.

7. Another work stands in a position to impair the interests at Venice more directly than the one extended by the United States.

8. The only riparian interest besides that of the ferry company is subject to the acts and obligations of the ferry company from whom that interest derives title.

Upon the facts recited above the conclusion is reached, in which I concur, that no damage has been done by works actually constructed by the United States to the riparian owners of lands or the improvements thereon at or near the town of Venice.

Concerning the second branch of the inquiry, what damages will be done by future works, a definite answer cannot be given. If the recommendations of the Board of Engineers convened in February, 1872, be strictly adhered to the damages will be large, and will depend upon the then value and development of the local interests. There being no immediate probability of these works being carried out, it would be useless to estimate these interests now, if the means of making such an estimate were within reach. As the question depends upon information obtainable only from the books, officers, and employés of the ferry company, the only mode of arriving at a valuation is through the courts.

To avoid the question of damages in future, I concur in the opinion that it would be well to modify the plan of the Board of 1872, and return to the lines agreed to and compromised upon in 1841 and 1849. To do this, however, would affect the interests of the city of Saint Louis in an important degree. Until the publication of this report and the accompanying papers affords an opportunity for the authorities of Saint Louis, and indeed all interested parties, to be heard, and possibly to suggest other solutions, I cannot indorse the recommendation of my assistant as to the immedate construction of the high dikes at the shore end of Bischoff's dike, and at the foot of Ferry street, Venice, for the construction of such works must depend upon their being accepted by the riparian owners in lieu of all possible claims for damage.

These conclusions are based upon an array of facts obtained with much labor from records and documents. In order to present the evidence upon which they are founded, a memoir* has been prepared, and is forwarded herewith, giving in narrative form a history of Saint Louis Harbor and the works for its improvement, to which a series of important reports is added as appendixes A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, and Q, in evidence of facts and opinions.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

* Memoir and appendixes printed in Senate Ex. Doc. No. 20, Forty-sixth Congress second session.

P 6.

SURVEY OF ALTON HARBOR, ILLINOIS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., February 9, 1880.

GENERAL: I have the honor to transmit herewith a tracing of the map of Alton Harbor, on a scale of $\frac{1}{5000}$, made in accordance with the river and harbor act of March 3, 1879.

* * * * * * *

The selection of the best plan for the "improvements proper to be made" at this locality being a problem of considerable importance, a Board, consisting of Capt. O. H. Ernst, Corps of Engineers, Mr. R. E. McMath, assistant engineer, and Mr. D. M. Currie, assistant engineer, was convened by me and ordered to examine and report upon the subject. The conclusions of the Board, whose report is appended, meet with my approval.

The plan proposed is to build a dike beginning at the point A, on the Missouri shore, about 1½ miles above the present dam across Alton Slough, and running diagonally downstream to the point B, a distance of about 4,800 feet, here making an angle of 10 degrees, and running hence nearly parallel to the Illinois shore towards C, as far as may be necessary; the top of the dike to be 14 feet above low-water; lines of hurdles to connect it with the Missouri shore at intervals of 400 feet.

Only the portion from A to B is to be built the first year, the estimated cost of which is $39,000. As the shoal yields to the eroding action of the currents, it may be extended. The amount of extension that will be required is uncertain, but its extreme limit will be 3,000 feet, the estimated cost of which is $32,000. The total estimated cost of the works completed is, therefore, $71,000, of which $39,000 may be advantageously expended the first year.

I regard the improvement as of value in the interests of general navigation, and the appropriation of the amount required for the purpose is recommended.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF BOARD OF ENGINEERS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., January 27, 1880.

COLONEL: The Board convened by your order of the 24th instant to "examine and report upon the best plan of improving Alton Harbor," have carefully considered the subject, and now respectfully submit their conclusions.

In selecting a plan of improvement, the Board have been governed by the following general principles: The works of improvement should be so located that they will probably harmonize with any plans which may in the future be adopted for the river above. The improvement of Alton Harbor requires, first, the removal of the shoal in front of the present city landing, and, second, providing a convenient landing on the Missouri shore for the Alton ferry.

The shoal in front of the landing at Alton is the natural result of the direction of approach of the channel, and the object of the works of improvement should be to so direct the channel that it will attack the shoal and flow more nearly parallel to the city front.

Following these principles, it is the opinion of the Board that the best plan for improving Alton Harbor is to construct a dike, beginning at a point on the Missouri shore about 1½ miles above the dam across Alton Slough, and running diagonally down-

stream a distance of about 4,800 feet, to a point near the foot of the great bar shown opposite the northern part of Alton, and about 1,300 feet from the Illinois shore, here making a small angle, and running hence nearly parallel to the Illinois shore as far as may be necessary; the reference of the top of the dike to be (96) or about 14 feet above low-water.

This dike collecting all the waste water of the river at stages below 14 feet, as in a funnel, and discharging it against the main channel as it passes down the Illinois shore, will tend to divert that channel while not coming in contact with it itself. It should at first be built only as far as the angle 4,800 feet from the point of beginning. It may afterwards be extended in the new direction as the shoal yields to the eroding action of the current as far as may be required. The extreme limit of this extension will be 3,000 feet, and that length is estimated for, though it is not probable that it will be necessary to extend it more than half that distance, if so far.

As the dike progresses it will be connected at intervals of 400 feet with the Missouri shore by lines of hurdles running perpendicular to it, and built to a reference (97).

A good landing is provided for the Alton ferry, just above the initial point of the dike. It is somewhat farther from Alton than the landing, which is now used at low stages, but it is near the landing which the ferry now uses at high stages.

In preparing the estimate of cost the Board has thought best to assume as a basis a form of construction, the success of which is tolerably certain—that is, for the main dike a solid structure. It is unanimously of the opinion, however, that some form of open construction, such as hurdles or buoyed curtains, should be experimentally tried in that part of the dike which is to be built in the water. Such work has never been executed upon the Upper Mississippi, and should be tried. It is not so promising there as below the mouth of the Missouri, where it seems to be succeeding. Accordingly the form of construction adopted as a basis for the estimate is, for that part of the dike built in the water, tiers of brush mattresses loaded with stone, built up to low-water mark, and above that level two rows of piles lined with boards and filled in with sand; for the part built wholly upon the dry sand-bar a bank of sand 10 feet thick on top, with side slopes of ½, faced with stone laid on by hand on the top and outside, and with a thatching of brush on the inside, and its foot protected on the channel side by a brush apron 50 feet wide.

The Board has no doubt of the beneficial effect of the hurdles which are to connect the dike with the shore. The estimate is as follows:

For part above angle:				
Dike in water 2,100 feet, at $6				$12,600 00
Dike on dry bar, containing for each running foot,	5 cubic yards sand, at 15 cents	$0 75	2,700 ft., at $2.30½.	
	9/10 cubic yards stone, at $1.25	1 12½		
	¼ cord brush made into apron, at $1.50	37		
	1/16 cord brush as thatch, at $1	06		
		2 30½		6,223 50
Hurdling 16,395 feet, most of it on dry bar, at 75 cents				12,296 25
				31,119 75
Contingencies, about 25 per cent				7,880 25
				39,000 00
For part below angle:				
Dike in water, 3,000 feet, at $6				18,000 00
Hurdles, 9,420 feet, at 80 cents				7,536 00
				25,536 00
Contingencies, about 25 per cent				6,464 00
				32,000 00
Total for the works completed				71,000 00

of which $39,000 can be advantageously expended the first year.

Respectfully submitted.

	D. M. CURRIE, *Assistant Engineer.*
	ROBT. E. MCMATH, *Assistant Engineer.*
Col. J. H. SIMPSON, *Corps of Engineers, U. S. A.*	O. H. ERNST, *Captain of Engineers.*
Approved.	J. H. SIMPSON, *Col. Engineers and Bvt. Brig. Gen., U. S. A.*

P 7.

SURVEY OF THE MISSISSIPPI RIVER OPPOSITE THE MOUTH OF THE MISSOURI.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., March 25, 1880.

GENERAL: I have the honor to transmit herewith a map, upon a scale of 1 inch to 1,000 feet, of the "Mississippi River opposite the mouth of the Missouri," made in accordance with the provision of the river and harbor act of March 3, 1879, by my assistant, Mr. P. C. F. West.

To show the changes that have been going on at this locality, I have had represented in broken lines the shore lines as they were found by the survey of 1870.

Immediately opposite the mouth of the Missouri the bank remained where it had been nine years before. This interesting fact is explained by the woods growing there. The greater stability of the bank stocked with trees over those cleared for cultivation is observable everywhere along the river, and it furnishes a reason why the navigation has been steadily deteriorating.

Just above the mouth a strip of land about 11,000 feet long has been washed away to an average width of about 325 feet, and below the mouth a strip about 12,000 feet long to an average width of about 675 feet. About 265 acres of good arable land has therefore been carried away. Estimating this land to be worth $50 per acre, the value of the property destroyed in the nine years is about $13,250, which is an average of $1,472 per year.

The obvious means of preventing this loss is to revet the bank. About 23,000 feet of bank would require protection, which, at $6 per foot, would cost $138,000. The annual interest upon that sum, at 4 per cent., would be $5,520, which is more than three times the present annual loss.

In the interest of the general navigation no improvements are "proper to be made" until the Missouri itself shall have been permanently rectified and have received a permanent mouth. Bank revetments are undoubtedly beneficial to navigation by cutting off the supply of channel-choking material, but their cost is so great that they should be constructed only at those places where the river is to be held permanently. To stop its inroads in one direction, leaving it free to alter its course in the opposite direction, cannot be regarded as judicious. A revetment opposite the present mouth of the Missouri might very easily find itself in a few years at a distance from the river.

The mouth of the Missouri is now 2 miles south of the position it held in 1870. In the mean time it has been still farther south, and it seems now to be moving northward. Works to give a permanent mouth to the Missouri could not be undertaken before that river had been rectified for a considerable distance above. The latter not having yet been projected, it is premature to discuss the former.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX Q.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS—SURVEYS AND IMPROVEMENTS AT VARIOUS POINTS ON MISSOURI RIVER—SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY—IMPROVEMENT OF ARKANSAS RIVER.

REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., September 10, 1880.

GENERAL: I have the honor to submit herewith my annual report upon the operations committed to my charge during the fiscal year ending June 30, 1880.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Q 1.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

During the past season three snag-boats were employed, viz, the J. N. Macomb and R. E. De Russy in the Mississippi and Missouri, and the C. B. Reese in Arkansas River. Twelve months' snag-boat work was accomplished, distributed as follows, viz: Mississippi River six months, Missouri River two months, Arkansas River four months. This time was well expended, all the boats worked very industriously, and, as the Mississippi work was done at a very low stage of the river, it was of great value. The work in Arkansas River was also very satisfactory, though the backwater from the Mississippi covered up most of the snags in the lower portion of the stream. The Missouri was so low that we were unable to do as much work as had been intended.

MISSISSIPPI RIVER.

Work on this stream extended from the mouth of the Missouri to the head of Deadman's Bend, a distance of 1,000 miles. The snag-boat De Russy left Mound City, Ill., August 16, 1879, and worked up to Saint Louis, which point was reached August 28. She then worked for about

a week in the Missouri River near its mouth, after which work was resumed in the Mississippi. The boat passed three times over the river between Cairo and Saint Louis, and on October 13 started from Cairo to work in the lower river. By November 1 she had reached Longwood Landing, where, being relieved by the Macomb, she worked back to Cairo and was laid up at Mound City, Ill., December 6, 1879.

The snag-boat Macomb, which had been detailed to the Missouri River in the early part of the season, began operations in the Mississippi October 7, 1879. She worked three times over the river between Cairo and Saint Louis, and November 4 started for the lower river. She worked down as far as Deadman's Bend, and turned back from that point November 18. The boat reached Cairo December 2, and was laid up at Mound City, Ill., December 6, 1879.

January 28, 1880, she again started out and worked up to Saint Louis and back, being laid up for the season February 14, 1880.

Table of work done in the Mississippi River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of miles run.
R. E. De Russy	1,133	27,458.6	31	19	1,8[illegible]
J. N. Macomb	389	4,349.7	629	....	2,6[illegible]
Total	1,522	31,808.3	660	19	4,46[illegible]

MISSOURI RIVER.

The snag-boat Macomb left Mound City August 10, 1879, and entered the Missouri River August 14. By September 10 she had worked up to Lexington Bar, 317 miles from the mouth, from which point she turned back and left the River October 3, to work in the Mississippi. In addition to this the De Russy did about a week's work near the mouth of the river in the beginning of September.

Table of work done in the Missouri River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of miles run.
J. N. Macomb	723	4,181.8	196	....	89[illegible]
R. E. De Russy	69	1,964.8	8	6	65
Total	792	6,146.6	204	6	963

ARKANSAS RIVER.

Work on this stream extended from the mouth to the head of Trustee Bend, a distance of 500 miles.

The new stern-wheel snag-boat Chauncey B. Reese, having been completed, left Mound City, Ill., for Arkansas River January 2, 1880. She

reached the mouth and began work January 7. After passing several times over the river between Little Rock and the mouth, she began work March 4 above Little Rock. By the 16th she had reached Trustee Bend, from which point she turned back. She left Arkansas River April 12 and returned to Mound City, Ill., where she was laid up May 5, 1880.

Table of work done in the Arkansas River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of miles run.
Chauncey B. Reese	750	15,212.7	488	19	1,962

Recapitulation of work done during the fiscal year ending June 30, 1879.

Name of river.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of miles run.
Mississippi	1,522	31,808.3	660	19	4,466
Missouri	792	6,146.6	204	6	963
Arkansas	750	15,212.7	488	19	1,962
Total	3,064	53,167.6	1,352	44	7,391

OBSERVATIONS AND SURVEYS.

Under the instructions of the department the field-work of the parties engaged on this work was closed up June 25, 1879, and the results of the various observations were turned over to Col. Z. B. Tower, Corps of Engineers.

CONSTRUCTION OF NEW SNAGBOATS.

Work upon the iron-hulled boats to carry the machinery of two of the old wooden ones was in progress during the season. One boat, the Chauncey B. Reese, was completed at the end of December, and sent at once to the Arkansas River. Her work there was of the most satisfactory character, and the boat seems well adapted to work on the smaller streams. She is a stern-wheel steamer 170 feet long and 36 feet beam. Her draught at stern, loaded, is 28 inches; at bow, 20 inches; mean draught, 24 inches. She has for snagging purposes four steam capstans, a pair of heavy iron shears, and a sweep-chain, while her bow and deck are suitably shaped and constructed to enable snags to be pulled in on deck and cut up.

A large force-pump was successfully used for loosening up logs and snags imbedded in the sand. Dynamite was also tried for this and other purposes, but without marked results.

The hull of the large side-wheel snagboat Horatio G. Wright was well advanced towards completion, but the exhaustion of the appropriation compelled a suspension of operations in the early winter. A few

months' work will complete this fine vessel, and it is expected that she will take the field in the fall.

When this boat is completed the work will be fairly equipped with large boats, and the Reese will probably be sufficient to take care of Arkansas River, but there is still great need of a boat of medium size which can be used at all seasons in the Missouri River. For such a boat we have the machinery on hand, and estimates for an iron hull are submitted herewith. It is intended during the present season to put a wrecking outfit on the wooden snagboat De Russy, and keep her at that special work hereafter.

The boat is old and requires extensive repairs to properly fit her for this work, and estimates for the purpose are submitted.

OPERATIONS FOR THE COMING SEASON.

The plans submitted to you contemplate the completion of the snagboat Wright and current repairs to the balance of the fleet, together with such snagboat work as the funds available will justify. It is thought that thirty-one months' work can be accomplished, distributed as follows, viz:

	Months.
Mississippi River	16
Missouri River	7
Arkansas River	8
Total	31

The work is situated in the collection district of New Orleans.

The amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1880, was $1,176,009.57.

The commerce benefited by the work is that of the entire Mississippi Valley.

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1882.

For building one small iron-hulled snagboat to carry machinery of one of present wooden boats	$105,000 00
For repairing one wooden snagboat and fitting it up for wrecking purposes	50,000 00
For working expenses of five boats, ten months each, at $4,000 per month	200,000 00
Total	355,000 00

Money statement.

July 1, 1879, amount available	$153,831 06	
Amount appropriated by act approved June 14, 1880	200,000 00	
		$353,831 06
July 1, 1880, amount expended during fiscal year		150,963 28
July 1, 1880, amount available		202,867 78
Amount that can be profitably expended in fiscal year ending June 30, 1882.		355,000 00

Q 2.

IMPROVEMENT OF MISSOURI RIVER AT SAINT CHARLES, MISSOURI.

Plans and estimates for the improvement of the Missouri River at this point were submitted to you under date of January 2, 1879. This report was published as House Ex. Doc. No. 60, Forty-fifth Congress, third

session, and was reprinted as Appendix O 17 to the Annual Report of the Chief of Engineers for 1879.

Congress, by act approved June 14, 1880, appropriated $25,000 for this work, which during the present season will be taken in hand and prosecuted in accordance with the plan proposed.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1880, was $1,176,009.57.

Money statement.

Amount appropriated by act approved June 14, 1880	$25,000 00
July 1, 1880, amount available	25,000 00
Amount (estimated) required for completion of existing project	55,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	55,000 00

Q 3.

IMPROVEMENT OF MISSOURI RIVER AT CEDAR CITY, MISSOURI.

At the date of my last report work was in progress on a mattress revetment along the front of Cedar City and on a floating brush dike designed to throw the river out of Cedar City Bend. This work was continued as far as the small appropriation would allow, a total of 1,100 feet of revetment being built and 1,900 feet of brush dike. The brush dike was only partially successful; the rest of the work has, however, stood well and the general results are satisfactory. The works will be extended during the present season.

Assistant S. W. Fox had charge of the work, with Assistant T. C. Bradley as local engineer.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1880, was $1,176,009.57.

Money statement.

July 1, 1879, amount available	$6,316 60	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$21,316 60
July 1, 1880, amount expended during fiscal year		5,902 63
July 1, 1880, amount available		15,413 97
Amount (estimated) required for completion of existing project		45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		45,000 00

REPORT OF MR. S. WATERS FOX, ASSISTANT ENGINEER.

SAINT LOUIS, *July* 7, 1880.

MAJOR: I have the honor to submit my report of the improvement of the Missouri River near Cedar City, Mo., for the fiscal year ending June 30, 1880.

At the close of the previous year, June 30, 1879, I submitted a report of the work done that year, a project for the expenditure of the funds available at that date, and a general plan with estimates for final improvement of the reach.

In accordance with the project work was continued on the weed dike commenced last year at the head of the bend.

The June rise greatly impeded the progress of the work. It was not until August 12 that the dike was completed. The amount of funds available at the time was so

small that field operations were stopped. The property was invoiced, and left in the care of a watchman at Cedar City. No attempt was made to collect physical data.

The dike was obviously designed to cause an accretion in Cedar Bend, and ultimately to shut off its water entirely.

The weeds were anchored in double line from the shore out 1,200 feet; from there a single line 700 feet long was put in, making an angle of 35 degrees down stream with the former.

The style of weed adopted was nearly identical with that described in my report last year of the improvement of the river near Glasgow, Mo.

The number of weeds in the dike was 314, the total cost of which was $1,545.98, or $4.92 per weed in place. A fill of 3 feet was recorded August 2, and another of 4.14 feet August 10; since then no soundings have been taken. With the exception of a shallow thread of water, which was at no time entirely stopped, the bend was dry during the low stage of river. After having been imbedded in silt and exposed for a length of time to the alternate action of sun and water, weeds are seldom able to rise, even if free to do so with a return of high-water. This effect is therefore temporary.

When I visited the work on the 22d of June, not 5 per cent. of the number of weeds put in were visible, the water being from 2 to 5 feet over them. But little damage was being done, however, to the bend below; fully 75 per cent. of the river passed down the channel next to the bluffs on the right bank.

In the upper bend the left bank had receded along its entire length, more noticeably, however, in the lower half. The point at the extreme lower end of the bend wears rapidly during a high stage of water; thus the crossing is lengthened and the pressure on the dike lessened. The increased pressure brought to bear upon the towhead has greatly diminished its size.

The bar in front of Jefferson City, which had been forming for some time previous to the construction of the dike, has disappeared, so that boats can land at any desired point along the town front. The revetment along the left bank in front of Cedar City is still intact.

Before closing I wish to acknowledge the services of Mr. T. C. Bradley, the assistant, under whose direct charge the work was carried on. Much credit is due to him for the intelligence and energy with which he acquitted himself.

I am, major, with great respect, your obedient servant,

S. WATERS FOX,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 4.

IMPROVEMENT OF MISSOURI RIVER AT GLASGOW, MISSOURI.

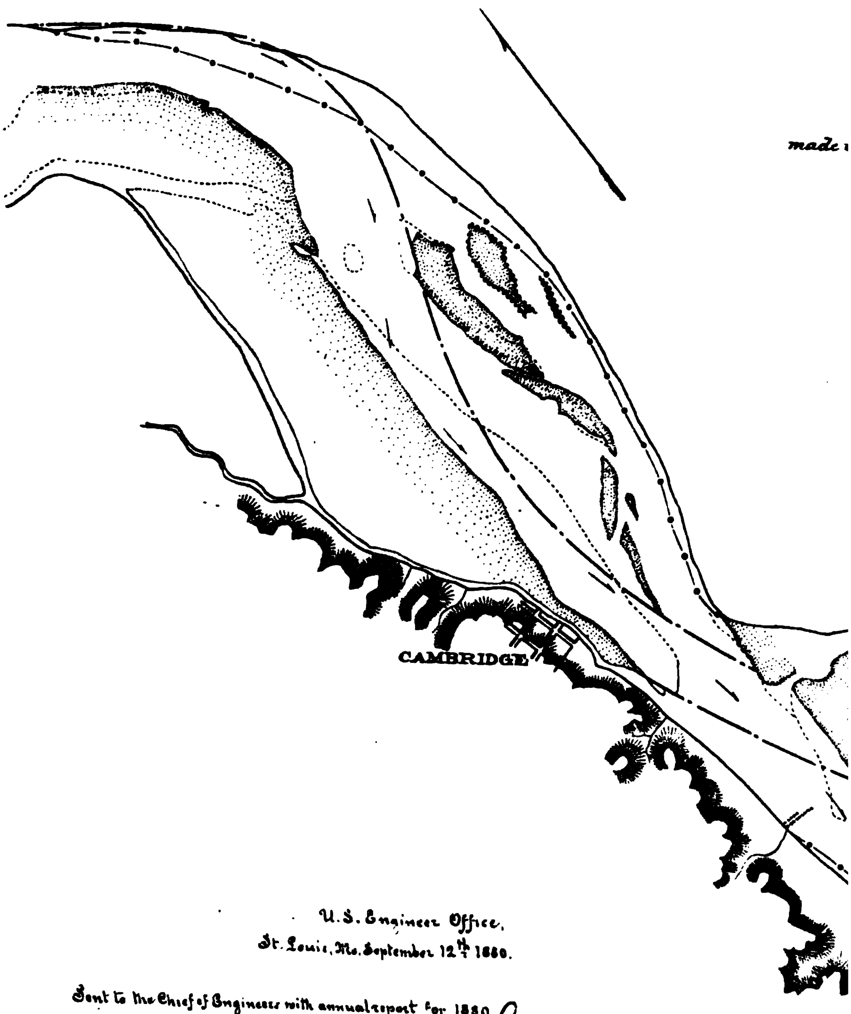
At the date of my last annual report a considerable amount of wo[rk] had been already done at this place in the construction of floati[ng] brush-dikes designed to force the river channel away from the rig[ht] bank of the bend above Glasgow, Mo. This work was continued duri[ng] the past season, 2,385 feet of brush dike having been put in and 1,9[..] feet of bank protection constructed. The results of this work ha[ve] been satisfactory, and the system will be extended during the prese[nt] season. The work was in charge of Assistant S. W. Fox.

The work is situated in the collection district of New Orleans, and the nearest p[ort] of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Saint Louis, Mo., during fiscal year ending June 3[0], 1880, was $1,176,009.57.

Money statement.

July 1, 1879, amount available	$9,642 24	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$29,642 [..]
July 1, 1880, amount expended during fiscal year		8,632 [..]
July 1, 1880, amount available		21,009 [..]
Amount (estimated) required for completion of existing project		98,000 [..]
Amount that can be profitably expended in fiscal year ending June 30, 1882.		98,000 [..]



U.S. Engineer Office,
St. Louis, Mo. September 12th 1880.

Sent to the Chief of Engineers with annual report for 1880.

Chas. R. Suter
Maj: of Engrs. U.S.A.

REPORT OF MR. S. WATERS FOX, ASSISTANT ENGINEER.

SAINT LOUIS, *July* 6, 1880.

MAJOR: I have the honor to submit my report and the accompanying map of the improvement of the Missouri River in the vicinity of Glasgow, Mo., for the fiscal year ending June 30, 1880.

At the close of the previous year, June 30, 1879, I submitted a report of the work done that year, a project for the expenditure of the funds available at that date, and a general plan with estimates for the improvement of the reach from Cambridge Bend to Glasgow.

It will be noticed that the project was not strictly adhered to, but revised at times to meet the demands occasioned by a change of regimen.

During the year there was constructed 2,385 feet of weed dike, and 1,900 feet of shore protection; these figures include the repairs made to dikes across No. 4, and to the shore-bar protection; in addition the railroad dike was repaired.

A hydrographical survey and two shore-line surveys of the entire reach were made and platted.

For a description of the weeds I beg leave to refer you to my report of last year. The shore protection is described in this report.

In accordance with the project the first work contemplated the completion of the weed dike at the head of the shore chute. The work was carried on under special difficulties, arising chiefly from exposure to the drift of the June freshet. When completed, July 9, the dike contained 60 weeds, anchored in double line from the shore 250 feet out. In a short time the chute was practically closed.

On the 14th of July work was commenced on the weed dike proposed for upper end of the middle bend. Ninety-four weeds were anchored in double line, from the shore out 450 feet. At this time the current made a long crossing from the left bank, at a point nearly opposite Cambridge, impinging on the right bank first at a point a short distance below the location selected for the root of the dike; here (and indeed for nearly the entire length of bend) the bank was caving rapidly. From the time of its completion to date, no erosion of the right bank below for a distance of 2,000 feet has occurred; a shore bar now extends from the dike down about 700 feet.

As the high-water passed off, it was noticed that there were several breaks in the dikes across No. 4 chute; these were repaired, and two auxiliary dikes put in, one at the upper end 200 feet long, and one at the lower end 100 feet long.

Work was then commenced at the railroad dike as proposed. Sixty-one weeds were anchored in single line, extending from the end of the solid dike. As the river was quite high at this date, it was thought best to wait for lower water before putting in the revetment proposed for the right bank below the railroad dike. On the 9th of August the entire force, with the exception of the watchman, a draughtsman, and a clerk, was discharged. On the 14th of August a cut-off occurred at Bushwacker Bend which shortened the river 5 miles, the fall in this distance being 5.2 feet.

On the 15th of August a reconnaissance of the entire reach was made, and the following notes taken, viz:

The current no longer followed the left bank of Cambridge Bend, but made a crossing through the bar and attacked the shore bar on the right, some distance above the front of Cambridge. This was a very desirable change, as it promised a landing to Cambridge. The current entered the Middle Bend in a direction parallel to the right bank, and was doing little damage except in the lower part of the bend; here a deep pocket was cut. The lower side of the pocket is composed largely of gumbo. From this the current was delivered in a direction compelling a short crossing to Harrison's Island. This condition of affairs caused the formation of the large shore bar, before which the Harrison Island shore line receded slowly. Leaving the island, another short crossing was made, the current impinging on the shore bar about 450 feet above the western end of the dikes across No. 4. The dikes were in comparatively quiet water, the current lying north of them and running parallel to them.

Before reaching the tow-head the current divided and entered three distinct channels. For convenience of reference I have numbered them, commencing at the left bank.

The head of No. 1 was quite shoal and very much obstructed by snags and rock heaps; there was a heavy draw over to it, however, and it is possible that a prompt removal of the obstructions mentioned would have rendered it a navigable channel.

No. 2 was a new feature in the topography of the river, and at that stage of the river was navigable; at the head there showed a 6-foot channel, with a bottom of compact gravel and occasional bowlders.

No. 3 was carrying 60 per cent. of the river. Its channel hugged the eastern shore of the tow-head, and delivered the water with a velocity of about 4 miles per hour against the main right bank, and in a direction approximating a normal to its shore line; consequently the caving was heavy. Below this, there was no change worthy of note.

On the 17th of August the watchman reported a slide of the bank immediately above and below the railroad dike, and that the dike itself had settled. After a close examination, I attributed the trouble to reef action above the dike, which, by causing excessive scour along the base on the upper side, cut through the stratum of blue clay or gumbo on which the dike rested, and attacked the quicksand underneath. The structure thus left without support settled, carrying with it as much of the bank as adhered to it. By means of brush weighted with bags of gravel and sand thrown in above and below, the scour was stopped, but not until the dike had settled 4 feet. In the mean time the river was encroaching on the shore bar at head of No. 4, and it became necessary to protect it.

It would have been advisable to have revetted it at once with brush-mattress work, but this method could not be entertained at the time, as it would have drawn too heavily on the allotment for the revetment proposed for the right bank below the railroad dike. The following method was adopted as an expedient, viz:

Large bundles of dogwood brush were sunk along the line of the old shore, the top being free and lapping each other; similar lines of brush were run out to this from several points on shore, thus forming a sort of hurdle system.

During the progress of the work, as an experiment, I had made 300 feet of curtain (identical in construction with the willow curtain described, and used first by Mr. L. E. Cooley, assistant in charge at Nebraska City); this was cut in lengths of 30 feet, and put in as a revetment at the upper end of the hurdle work just described. This work was completed August 24. At that date, No. 4 was silting up very rapidly, and revetment seemed unnecessary, as far down as the point where the current from No. 3 impinged on the right bank; here and for some distance below, as already stated, the caving was heavy. To hold a bank successfully under such conditions as obtained here would require a revetment that would follow the scour to its last limit if necessary.

With the hope of avoiding so expensive a revetment, it was thought advisable to construct a weed dike at the head of No. 3, that would throw the channel further down, if not entirely out of the chute. About 300 feet of the dike had been completed when orders were received to suspend.

On the 22d September, the property was taken to Glasgow, and an inventory made; the boats were hauled out on the bank and covered, and the smaller articles stored in a warehouse.

On the 26th a shore-line survey of the reach was commenced. It was finished on the 29th. On the 25th of October a break occurred at the upper end of the shore bar protection, and by the 1st of November nearly all of the work had been carried away. On the 3d of November preparations were commenced for revetting the bar with curtains. The method of construction was as follows, viz:

Willow brush was selected of lengths not less than 35 feet, and from 2 to 4 inches at the butts. Seven (men) weavers, provided each with two shuttles of No. 11 wire, were distributed along the length of the brush at distances of about 4 feet. The wire from each shuttle being made fast to the first brush, one of each pair was laid back from the weaver, and the other retained in the hand; a second willow was then laid on the wire parallel to the first and pressed close to it; the shuttle held in the hand was then laid back from the weaver and the other taken up, when a third willow was laid in and the operation repeated. Thus the wire from each shuttle passed alternately over one brush and under the next. When five pieces had thus been woven in, a close twist of about 3 inches was made by a rapid exchange of shuttles from one hand to the other. The weavers receded from the start in straight lines parallel to each other. They were made on the ground where the brush was cut, and rolled up in lengths of 75 feet, this being as large as could be conveniently handled. Seven weavers with one helper will weave 15,000 square feet per day of ten hours. Six of these rolls were made and taken to the upper end of the caving bar and unrolled on the water; they were then floated into position and linked together so as to form a continuous revetment, the brush lying normal to the shore line. After the upper end had been well loaded and sunk, it required very little additional weight to bring the entire length in contact with the bottom.

On November 11 the river commenced to rise, and in a few days was 7 feet over the shore edge of the revetment.

The work was visited November 20. The revetment was intact, but the high-water had cut a bench back over it in places 25 feet. About 275 feet of the old dike across No. 4 had been entirely washed out. A strong current was running through the gap and had already scoured out a considerable channel through the deposit. Instructions were received to continue the revetment to the old line of dike, and to close the *gap* with curtains. Accordingly 600 feet of revetment and 485 feet of curtain dike was put in. The revetment was constructed in the same manner as that just described. The curtains for the dike differed from those of the revetment only in that the brush was woven from 6 to 10 inches apart, the wire being twisted between each brush. They were anchored in lengths of 75 feet, the height of the curtain being the length

of the brush. The floats were water-tight boxes 1 foot × 1 foot × 5 feet. The anchors were crates of willow filled with broken rock. This was the last work done.

In December and early January chute No. 4 was dry; No. 3 was very shoal; while No. 2 was carrying from 65 to 70 per cent. of the water. Soundings showed a scour at its head of 6 to 9 feet

June 17, the reach was visited and the following noted, viz: The right bank in front of Cambridge had worn back within a few feet of the old city wharf landing. A crossing was made from the wharf to the left bank at the head of Harrison's Island Chute, where some cutting was taking place. From a point nearly opposite the dike in the middle bend, the current divided and entered two channels; one hugging the shore line of the right bank, the other shaping around next to the island. The two uniting again at the lower end of the bend, and here the right bank was cutting rapidly. Considerable water was running in No. 4 through a break at the lower end of the dike. The shore protection was intact; No. 3 was quite shoal, but was evidently scouring out. No. 2 was carrying the most water.

The year's work has afforded opportunity for the study of the merits of individual weeds in permeable dikes. The results obtained from weeds of the Brownlow type were never complete, and always temporary. In a dike constructed of them there will necessarily be large openings between the weeds (especially near the bottom) through which water will flow with disastrous effect to the accretions below. This action becomes more apparent as the branches of the weeds clog up with rootlets and the usual débris of silt-bearing rivers, oftentimes producing sufficient scour around the anchor to carry it and the weed many feet out of line. The continued motion (often one of rotation about the core as an axis) causes the loss of a number of weeds by parting the connection at the anchor. If a float is defective, or becomes detached, the weed to which it belongs is lost. A break in a dike of this kind, if not closed promptly, will widen.

The most essential requisition of a permeable dike is, undoubtedly, homogeneity. This has been nearly realized in the curtain dike, which is very effective.

It is necessary to provide some means for their support other than floats, which, if not detached by drift, or made ineffective through a leak, will be dragged under in time by the pull on the curtain. A framing has been suggested and will, I think, prove effective.

The curtain revetment described has been successful, and its use is recommended in similar cases.

Since the survey of the reach in November, 1878, there has occurred no change in the regimen of the river which would necessitate an important change in the general project for the improvement of it, as submitted to you by Capt. Thomas H. Handbury, Corps of Engineers, U. S. A., in a report dated January 16, 1879.

The proposed shore lines are shown on a tracing which accompanies this report. In brief, it is proposed to effect a permanent shore line in the upper portion of Cambridge Bend, from which a crossing will be made to the bluffs of Cambridge, when the current will be held parallel to a revetted curved shore line, down to the point where a second crossing will be made to the bluffs of Glasgow.

It is impossible to anticipate with certainty the details of construction. In general terms, permeable works will be used to rectify the shores to the desired aligment, when they will be revetted if necessary.

A Long's scraper, or similar appliance, could be used to advantage in such places as at the heads of Nos. 1 and 2, where it is desirable to deepen the channel through gravel and bowlders, material too heavy to be removed by any ordinary current.

Before closing, I wish to acknowledge the valuable assistance rendered by Messrs. James Sanderson, Arthur J. Frith, and others of my corps of assistants.

I am, major, with great respect, your obedient servant,

S. WATERS FOX,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 5.

IMPROVEMENT OF MISSOURI RIVER AT LEXINGTON, MISSOURI.

The situation at this place is very similar to many others on the river where improvements are now in progress; that is to say, the rapid erosion of the left bank in the bend just above Lexington is allowing the whole river to move bodily down stream, and if not checked will soon

destroy entirely the harbor and boat-landing at Lexington. The plan proposed contemplates the protection of caving banks by brush-mattress revetments, and the construction of floating dikes, designed and located so as to rectify the channel. The appropriation made by Congress at its last session will be expended in the prosecution of this plan.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30 1880, was $1,176,009.57.

Money statement.

Amount appropriated by act approved June 14, 1880	$15,000 00
July 1, 1880, amount available	15,000 00
Amount (estimated) required for completion of existing project	35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	35,000 00

Q 6.

IMPROVEMENT OF MISSOURI RIVER AT KANSAS CITY, MISSOURI.

Work at this point consisted in repairs of the floating brush dikes, constructed earlier in the season, and in the building of 5,042 feet of bank revetment above the shore end of the brush dike. These works have given satisfaction, and will be continued during the present season. The revetment used was very cheap and efficient; a description will be found in the appended report of Assistant John W. Nier, who had charge of the work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$22,667 53	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$47,667 53
July 1, 1880, amount expended during fiscal year		22,510 57
July 1, 1880, amount available		25,156 96
Amount (estimated) required for completion of existing project		37,810 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		37,810 00

REPORT OF MR. JOHN W. NIER, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *July* 5, 1880.

MAJOR: I have the honor of submitting the following report of operations on the improvement of the Missouri River at Kansas City, Mo., for the fiscal year ending June 30, 1880. The work of the past season has been that of completing the weed dike in process of construction at the time of making my last report, and the revetment of the banks in Upper Kaw River Bend. At the conclusion of this portion of proposed improvement, the entire appropriation made for this work was expended and operations were forced to a close for the want of funds. It is to be regretted that the amount available for expenditure on this work was so small.

The radical changes that the Missouri River constantly undergoes makes it exceedingly difficult to locate with any degree of permanence any construction, when the scanty funds through necessity make it very limited in extent. On every improvement of a special reach on the Missouri River, there are certain points or reaches

whose protection from the first commencement becomes vital to the plan or scheme upon which the estimates for the cost of the entire work is made. These places are, after being suitably protected against all ordinary contingencies which may arise, subject to the full force of the current striking them at angles, the sole cause of which is a change in the stream bed on some reach above which has been necessarily neglected through a too limited appropriation. The succeeding appropriation must then be used, in part, to repair damages arising from floods and other causes, which could have been avoided had the work been sufficiently extensive. The amount of repairs done because of the very limited work put in last season has been small, yet it has been sufficient to reduce the sum total of work done below that estimated as possible with the amount available for such purpose.

The effect of the short weed dike constructed last year has been marked. Its effect was to direct the current towards a chute on the Kansas side of the river through which during the June rise the main discharge of the stream took place. The immediate effect of this shifting of the current was the enlargement of the chute both by scour and erosion of the banks and bars, until a cut-off occurred through a large island bar, when the stream again shifted through the head of the bar. This bar was about 4,600 feet in length and lay between the chute and the concave portion of Lower Kaw River Bend, which had previously been the main channel prior to the June rise of 1879. The old channel in the lower bend by these changes became the receptacle for a large amount of drift and sediment which accumulated so rapidly that the low-water depth was reduced from 30 feet to 10 feet, while it contracted from 1,200 feet in width to 150 feet. What was the main channel of the stream is now nothing more than a narrow chute separated from the new channel by a large crescent-shaped bar. Had the June rise been of the usual duration the results of the work would have been even more beneficial. These results, which are directly attributed to a small but efficient construction, point to the feasibility of removing the river from Lower Kaw River Bend and averting the danger of a cut-off north of Kansas City Bridge.

The Kaw or Kansas River, whose junction with the Missouri is but 1¼ miles from Kaw River Bend, exerts a marked influence upon this portion of the river During the summer months it is liable to frequent and rapid rises, caused by heavy local rains for which the locality is noted. The discharge of the stream at such times is very large and causes a backing up of the waters of the Missouri. An unusual deposit of sediment in the Missouri then occurs, which in turn during declining stages is again picked up and carried off. This action tends to add to the instability of the stream by aggravating the erosion of the banks.

To arrive at intelligent resul s in connection with construction work, frequent surveys and observations on its effects are necessary. These were made as often as desired and consisted of two surveys extending from Quindaro to Kansas City Bridge, and regular observations on cross-sections.

Cross-section work was confined to the sections laid out in June, and a new set laid out in the same locality, those laid out first becoming useless for further observation after the June rise, because of changes in the channel. A set of sections extending along the revetment work 100 feet apart was laid out and sounded once for future reference.

The surveys from the bluffs at Quindaro to Line Creek Crossing show a constant recession of the shore line by a uniform rate of cutting of the banks for a distance of 2 miles below the bluffs. This, it will be seen, is working a change that must shortly threaten seriously the success of any work put in Kaw River Bend. A careful study of this portion of the river shows the necessity of confining at least a portion of a season's operations to stopping the cutting along these banks and contracting the channel on the crossing opposite the mouth of Line Creek. It is believed that with the stopping of erosion of the banks below Quindaro Bluffs that work can be continued intelligently with assurances of success; otherwise any construction in Kaw River Bend will in a measure be temporary only, so long as that part of the stream is left to take care of itself.

No observations with a view of acquiring physical data in the hydraulics of the river were undertaken, although some preliminary steps were taken with that end in view, yet the limited amount of available funds did not allow of securing additional help, while the force at my command was inadequate to the task.

In the month of June, 1879, a number of "tree weeds," with oil barrels as buoys attached, were, by the accumulation of drift upon them, pulled out of the dike, causing breaks or openings through which the water rushed, destroying to a large extent its efficiency. These breaks were closed up by the employment of weeds of similar design to those pulled out. Some additional weeds much larger than any previously used were placed where settling or sinking of the dike appeared to have occurred. In July a violent eddy, evidently caused by the shore end of the dike being too solid, cut a large semicircular pocket into the bank, its diameter being about 200 feet and a depth of water 30 feet. The sudden development of an eddy of such unusual violence at this point required prompt action to prevent the destruction of the dike by cutting

off its shore connection. This was effectually done by using a large number of tree weeds which had been made for such an emergency in June and placed upon the bank. These weeds were planted in parallel rows across the throat or mouth of the eddy when the force of the current was broken, and it silted up and became solid in a few days.

After carefully observing the workings of tree weeds, I am convinced that something more homogeneous in its resistance to the current can be used to accomplish the results arrived at in the employment of weeds of that kind. Any sudden change in the direction of the current finds new openings through which the water passes, causing scour around the anchors and allowing them to sink until a considerable amount of the water passes over the top and not through the dike as intended. The resistance to the current is therefore lost and their effect but slight after being planted for some time The tendency of the weeds is to gradually work into a small compact roll of less than ½ the sectional area they had when made. This is invariably the case, despite all care taken in making them. A constant reduction in the resistance section of any dike of this kind must therefore be encountered that in time must cease to make it effective.

The experience acquired by the season's work on the continuous woven mattress shows the feasibility of continuing a wire curtain or woven mattress weighted upon one edge and held up by buoys on the other along a proposed shore line, and inducing deposit behind it. The mattress would then become a revetment of the new shore, which would be free from the spurs or points found in revetted bends.

Revetment work commenced September 11 and closed October 22. This work commenced at a point about 3,000 feet below the mouth of Line Creek, and extended to the dike, a distance of 5,042 feet. The mattress is a continuous web of woven wire and brush 92 feet wide, extending from the top of the bank to the bottom of the river. As the details and manner of construction are somewhat different from other works upon the river, a description, with tracings illustrating the methods employed, is given. The mattress was built upon thirteen ways mounted upon a boat of the ordinary scow pattern 60 feet in length and 14 feet wide, with a gunwale 3 feet deep. The ways were supported by posts resting upon the gunwale of the boat, the entire system of ways and posts being thoroughly bolted together. A sufficient treadway between the ways and deck was allowed to permit of the free passage of sewers and men employed upon the under side of the mattress. A platform 10 feet wide extending the full length of the boat, elevated 10 feet above the deck, and even with the upper end of the ways, was used by the carriers and tenders who delivered the brush to the weavers.

The arrangement of ways and platform distributed the moving load on the boat, and the suspended mattress on each side, so that listing or capsizing was avoided. The method of mattress construction is as follows:

The boat is taken to the head or commencement of the work and held transverse to the current, the shore end of the boat being a few feet from the bank. After the bank has been graded for a short distance to a slope of from 1¼ to 1, the work of weaving was commenced by first placing several pieces of straight brush parallel to each other upon the graded slope. Other pieces are then placed at right angles to those first laid down. The stub ends of separate pieces of brush are then pushed through the openings or meshes, and sprung down and held in position by the weaver who places the succeeding pieces at right angles to this, and in such a manner that the last piece being held in position securely binds those first laid down. This is accomplished by alternating the direction or position of each piece of brush as it is put in. As several weavers follow each other across the mat, care is taken to reverse the work at every mesh. Special attention is given that the ends are well pushed under as each piece is put in, thereby preventing, to a certain extent, unraveling. The mattress, when completed, somewhat resembles crate-work, except that twisting is not resorted to. The finer portions of the brush are always on the under side of the mattress, while the stems or trunks form its upper surface. The methods employed upon the boat are the same, except that the first few courses are tied to the ways with marline to prevent their slipping off. After the mattress has been woven for several feet a set of (8) mattress hooks are hooked into it and the marline lashings cut. The mattress is then held in position on the ways by these hooks, and is allowed to slip when desirable. Two independent sets of hooks are employed. When one set has slipped some distance the second is inserted and the first is unhooked. A rope 10 feet long is fastened to each hook, the end being passed over a cleat or kevel. This arrangement allows either end of the mat to slide at will, so that the boat may be passed around spurs or pockets on the bank. When the mattress built upon the boat reaches the water's edge it is connected to that built upon the bank by a woven joint. This operation is one that requires special care, in order that the joint will be as strong as the remainder of the mattress, and resist the strains placed upon the work when sliding off the mat upon the bank itself occurs. To add to the strength, and obviate any raveling or fraying out of the woven work, wire was extensively used. The sizes commonly used

were Nos. 10, 12, and 14 annealed-iron wire. Seams, both longitudinally and transversely, were sewed in the distances apart varying according to the locality in which the work was being placed. Six seams of No. 10 wire were carried longitudinally on the outer edge of the mattress 2 feet apart. This was necessary, as at all times the heavier strain was on that portion of the work. Through the remainder of the mattress the seams were 4 feet apart and of No. 14 wire. Transversely the seams run 6 feet apart and of No. 12 wire. The tool used for sewing was the harpoon shuttle introduced by Assistant Cooley, and answers admirably the purpose for which it is used. Sewing upon the bank was done by using a curved or "bag-needle" of round iron.

The employment of wire in woven-mattress work was considered essential from the first commencement of mattress work. In woven work, when coarse and scraggy brush is wholly used, no system of weaving can be employed which will prevent the unraveling of the work. Every turn or bend that it receives allows it to enlarge the mesh by slipping of the fibers of brush over each other. The average thickness of the mat built was from 5 to 6 inches. When fine, long brush could be obtained, thickness was even less than these dimensions The arrangement of plant is explained by tracings. The method of sinking is simple, but requires care in securing the head or commencement of the work. Sisal rope is thoroughly woven into the first 10 feet of the mattress, the ends being worked into loops to which safety lines were attached. The safety lines were drawn tight and fastened upon the bank about 200 feet above the boat. Several tons of rock were then tied on the mattress causing it to go directly to the bottom as fast as allowed to slide upon the ways. After about 100 feet of mattress was completed the lines were withdrawn and the rock simply thrown upon the mattress from flat-boats. An average of 4 or 5 pounds per square yard of mat surface is all the rock necessary to hold it in position except at the head of the work, when 25 or 30 pounds were used.

The progress of the work during fine weather was quite satisfactory. The labor, although unskilled, readily learned the routine of the work. The greatest day's work was 220 feet, with a working force of 45 men. With a few changes in the plant used this might be made an average day's work. Frequent delays from bad weather and a scarcity of men were encountered.

The removal of snags along the bank to be reveted was the most difficult task of the season. The great number that had lodged on the lower half of the work formed a perfect barrier to further progress until they were removed. This required the organization of a separate party, who, being equipped with a complement of tools, flats, and ropes, succeeded, after considerable trouble, in removing those near the shore. The experience acquired in this portion of the work proved conclusively that the appliances in use by construction parties are too light to deal with such obstructions.

A summary of the work done, cost, table of disbursements, &c., are herewith submitted.

In connection with this report I submit a reduced map of Kaw River Bend. This map is from a survey made in October, and has located upon it the work completed during the past fiscal year and the dike built in June, 1879.

A tracing is also submitted showing the mattress boat used in building the continuous mattress.

The sketches, figures 1 and 2, represent a general arrangement of boat and lines with the mattress in process of construction.

Figure 3 represents a sketch of a section of bank with the average width of mattress lying upon it, with the outer edge in the deepest water found on the entire reach.

Figure 4, the mattress hook used in holding the mat.

Figure 5, mattress hook in position, showing method of keeping the mattress in place.

In conclusion, I wish to acknowledge the services of W. H. Byran and E. C. Shankland, assistants, and J. H. Simonds, foreman on construction.

I am, major, most respectfully, your obedient servant,

J. W. NIER,
Assistant Engineer.

CHARLES R. SUTER,
Major of Engineers, U. S. A.

Q 7.

IMPROVEMENT OF MISSOURI RIVER AT FORT LEAVENWORTH, KANSAS.

Work at this place during the past season was confined to repairs of old work and to the construction of 1,570 feet of new revetment above Bee Creek Point. Three hundred feet of brush dike was also put in opposite the town of Leavenworth. The appropriation now available

will be expended in extending the revetment and in works of channel rectification.

Assistant D. W. Church had charge of this work, with Assistant G. T. Nellis as local engineer.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$9,337 48	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$17,337 48
July 1, 1880, amount expended during fiscal year		8,886 13
July 1, 1880, amount available		8,451 35
Amount (estimated) required for completion of existing project		27,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		27,000 00

REPORT OF MR. D. W. CHURCH, ASSISTANT ENGINEER.

ATCHISON, KANS., *May* 24, 1880.

MAJOR: I have the honor to submit the following report on the work of improving the Missouri River in the vicinity of Fort Leavenworth, Kans., from July 1, 1879, to March 31, 1880.

The maps and drawings which properly belong with this report have already been submitted.

The condition of the river has been such that no material deviations from the plan previously decided upon have been necessary. One thousand five hundred and seventy feet of revetment was put in during the season above the mouth of Bee Creek, and small additions made to the weed dike at the head of Leavenworth bar.

In my report for the fiscal year ending June 30, 1879, mention was made of the breaks which occurred during May and June, 1879, in the revetment connecting the upper and lower works of 1878. These occurrences were repeated at intervals during the month of July and until the 4th of August. The stage of the river at the time of the last break was 2½ feet higher than that at which the first appeared, indicating that the attack upon the revetment was less severe after the deep scour of high-water.

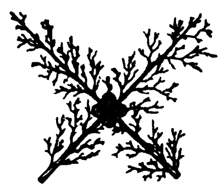
The explanation for the occurrence of these breaks offered in the report previously mentioned was, that as the high-water scour extended below the outer edge of the mattresses, the quicksand floded from underneath and allowed the revetment to settle. While the above explanation is thought to be the correct one, it is possible that the caves may have been caused in some cases by underground drainage from the adjacent low lands and lake. In one instance where soundings were being made, a great bubbling of the water was seen near shore, and anticipating a cave the sounding-pole was forced through the mat as far as possible. The cave which took place immediately after produced no movement of the pole or mattress, and the bottom was found to be solid at every point except along shore. The mattress was everywhere well filled with sediment. Near shore the bottom was soft and the mat outside covered with earth seemingly from the bank. When final repairs were made the bank from one break to the next was covered with the same form of mattress as that used where the caves occurred. It consisted of two layers of brush at right angles to each other bound with small fascines and wire. Two flat-boats were placed in train along shore and way poles laid from them to the top of the bank. Upon these fascines were laid parallel to the bank and 6 feet apart. The first course of brush was laid perpendicular, and the second parallel to the river. Fascines were laid on top every 6 feet perpendicular to the river and bound to the lower ones at every crossing. The ways were then pulled from under the mat with a tackle. The protection thus made was about 10 inches thick, and lapped the mat below water about 6 feet. The cost of this work ($576.85) was greatly increased by the irregular manner in which it was done.

Since July 1 very little has been done towards closing the chute on the Missouri side of Leavenworth bar. The action of the dike constructed in June (called for convenience No. 1.), was closely watched in order that auxiliaries might be put in to aid it if necessary.

As the high-water subsided a small bar made its appearance about 800 feet below

No. 1, with a strong current inside preventing its extension shorewards. In order to close this channel and force all the water going behind the main bar through one entrance, a dike 300 feet long, made of horizontal weeds, was placed across it.

The construction of this dike was different in detail from that of No. 1. Three slim poles (made equal to the length of weed desired by splicing) were laid parallel to each other, and 8 or 9 inches apart, upon a rack which held them about 3½ feet from the ground. Two men, one on each side the poles, working alternately, each placed his brush over the two poles nearest him and under the one farthest from him, forming a letter X over the middle pole. Each successive cross was placed close to the preceding until the length of poles had been taken up, when a fourth pole was placed on top, and the four tightly bound together every 3 feet. When completed there was a pole in each of the four external angles of the cross, as shown by the accompanying sketch of a transverse section of weed. This weed could be made of any length desired, and its simplicity makes it a cheaper form of construction than the old one of tying or nailing brush to a bushy sapling. It was anchored in the same manner as the horizontal weeds used in dike No. 1.



This second dike soon connected the small bar with the shore, and, by closing the channel, caused a large deposit above. The two dikes combined, although inadequate to the work of completely closing the main chute, have acted very satisfactorily in extending the Missouri shore. The blue line upon the map shows the low-water shore of 1878, and the black that of October, 1879. It will be seen that the extension of the Missouri shore has in some places reached a width of 650 feet. In September, 1879, the entrance to the chute was but 200 feet wide, and had an average depth of 3 feet. It was well filled with snags, and the current was moderate.

The results obtained from the small amount of work done show that the chute can be completely closed without great expense. The work for that purpose could be put in most advantageously in winter or spring.

About September 1 the lodging-houses were moved to a suitable point preparatory to commencing the revetment above the mouth of Bee Creek.

In determining what width of low-water revetment was necessary at this point consideration was taken of the fact that at no season would the work be severely tested. Soundings were made near shore, and a width of 65 feet decided upon.

The mattresses used on this work were similar to those made without the use of poles in April and May, 1879, and described in my report for that year. They were constructed upon elevated ways, and consisted of a single layer of brush bound with fascines. At first fascines were used both on top and underneath the mat, but in consequence of their cost efforts were made to determine the minimum number necessary to give the requisite strength and stiffness. Accordingly, the number was gradually reduced from twenty-four at the first to eight placed 10 feet apart on the bottom of the mat. The seams, as in other cases, were 5 feet apart, those intermediate between fascines being sewed with two shuttles in such a manner as to always have a wire both above and below the brush. The stitches were locked so that no slipping would take place should the wire be broken at any point. This mattress was found to be so flexible that it could not be held in the current and properly sunk, but as unusual difficulties arose in floating it was thought advisable to construct a second in the same manner, so that the question might be fully tested. The same trouble was experienced with this one as with the first, after which no experiments were tried, but the mattress having fascines 5 feet apart on the bottom and none on top (16 in all) was adopted. In making these mattresses particular attention was paid to the quantity of brush used, the arrangement of the men, and the method of sewing. The brush was all laid in one direction (perpendicular to fascines), and had when bound an average thickness of 6 inches. One shuttle was used in sewing, and a half hitch taken with the wire every 5 feet, the shuttle being passed once through the mat and around the fascines between one hitch and the next. The shuttles used were made of wood and tipped with steel, as shown in the sketch. Three stout poles were stitched to the up-stream edge of the mattress, around which the three lines used in floating were passed. The down-stream inshore corner of the mat was frequently pressed with great force against the bank before it was finally brought to place. To stiffen it at this point two poles intersecting at the corner were lashed on top. These were taken off as soon as the mattress was in position. In sinking the mat the flat-boat was placed at right angles to the bank over the up-stream edge. Sufficient stone was then placed along this edge and on the outside corner to sink them well and prevent the whole from moving. From 2½ to 4 tons (2 to 3 cubic yards) was required to accomplish this. Earth was then wheeled out from shore on the boat and distributed over the mat until the down-stream portion was firmly placed on the bottom. The labor

and stone for sinking in this manner cost 14 cents per linear foot of shore. On the "lower" work of 1878, 40 feet wide, and on the "upper" work of the same year, 75 feet wide, the stone alone cost, respectively, 13¼ and 22 cents per linear foot.

The banks above the water line, which are composed of a dark clay approaching gumbo, with sand in places, had been left quite well sloped by the last high-water, and consequently were easily graded. The slope was made about 1¼ to 1, and cost for grading 6 cents per linear foot.

The high-water protection was woven after the method employed this season at other points on the river, and was extended on to and interwoven with the mattress work below the water line as much as possible, so as to make the two continuous. Inasmuch as no men were available who had ever practiced or seen this style of work, the progress at first was very slow, but as the men became familiar with the work excellent headway was made. The brush used being principally dogwood, and very coarse, it was impossible to make a uniform and neat-looking piece of work with it. After the receipt of your letter of October 20, 1879, directing that the work be closed for the season, the high-water protection was made much thinner in order that the brush already on hand might be sufficient to complete the revetment. The liability of the bank to severe attack not being great, the thin upper bank protection is deemed sufficient. Its cost was 24 cents per linear foot, which is but from one-third to one-half the cost of that previously used on the Leavenworth work.

The total length of mattress work below water was 1,570 feet, while that of the high-water revetment was but 1,510; the mattress farthest up stream, which was separated from the rest by a small gumbo point, being left without upper bank protection.

The total cost of the revetment per linear foot, including construction of ways, making roads, &c., was $1.75 1/10.

The surveys made during the season were especially intended to determine points of local interest, such as the effects of work done and the nature and effects of natural changes. For this purpose cross-section hubs were located 1,000 feet apart from about 4,000 feet below Weston to the north line of Leavenworth, and numbered each way from zero at the bridge. These sections were sounded in July, September, and October, each sounding being located.

Levels were run and carefully checked over this portion of the river with benches every 2,000 feet, at which points the slope was taken when the sections were sounded. The levels were connected with the benches of the Kansas City, Saint Joseph and Council Bluffs Railroad, and referred to the same datum.

At the close of the work in October a complete low-water survey was made from the mouth of Kickapoo Slough to lower end of Leavenworth Bar near East Leavenworth, and from this survey all shore and channel bars shown on the map in full black lines have been platted. Numerous minor surveys were made in the vicinity of the brush dikes. The sectional soundings were platted on stiff paper to a horizontal scale of 100 feet to the inch, and the portions below 4 feet on the Fort Leavenworth gauge carefully cut out and balanced upon the point of a needle to determine their centers of figure. The centers were then platted upon the map, and those corresponding to the same survey connected by lines. It was intended to show by the different positions of these lines what horizontal movement took place in the deepest portions of the bed between high and low water, also what changes were effected by the cutting away of Bee Creek Point or any other eroding bank. These lines, instead of giving directly the position and direction of strongest current, indicate merely its general effect, and may be situated at points where the water is shoal with a channel on either side.

It will be seen from the line of July 26, when the Fort Leavenworth gauge read 12.25 feet, that during high stages the stream does not enter the sharp curve in the shore line above Bee Creek, and that after passing △ 17 the deeper portion of the channel bears away from the left bank. Below the bridge the high-water line is nearer the Missouri shore than those of lower stages, and as the river falls there is a slight movement towards the right bank. The line corresponding to surveys of October 27, when the gauge read 4.35 feet, follows more uniformly the curve of the shore line below the root than any of former surveys, which I think may be attributed to the cutting at Bee Creek and the corresponding lengthening of the lower bend. No changes at present noticeable below the bridge can be reasonably attributed to the recession of Bee Creek Point.

The points of greatest variation between lines corresponding to different stages are located one a short distance below the root and the other opposite the mouth of Kickapoo Slough. The former is principally due to the sharpness of the bend, and will probably cease when the proposed shore line above that point is reached. The differences at Kickapoo Slough are due to the fact that at high-water the greater portion of the stream passes on the Kansas side of the Weston Island, while in low-water this channel is nearly closed. In a perfectly stable river the center of the low-water portion of cross-sections would correspond at all stages, and the variations between them show the points where rectification is necessary.

The slopes plotted on the map are those taken August 29, 1878, December 2, 1878, July 28, 1879, and November 1, 1879. It will be seen that the slope of the river in its passage from the Missouri to the Kansas bluffs is much greater than it is either above or below, where in both cases it flows along the bluff in a path nearly straight. Some of the causes which tend to increase the slope in the bend are, first, the greater frictional surface presented in the wide crossing; second, the energy expended in undermining and carrying away caving banks; third, the energy expended in excavating channels rendered necessary by changes in direction of current, the latter being caused by new shore lines along eroding banks and by differences in stages; and, fourth, the resistance due to the sharp bend at the fort and smaller bends above. The first three mentioned causes of increased slope will, it is believed, be greatly reduced with the completion of the present project and the building up of shore bars above the plane of overflow. It will be seen that both the high and low water slopes of 1879 are more uniform than those of 1878. This would necessarily follow the protection of banks and reduction of shore line curvature to uniformity.

As the project for future operations now stands, it contemplates the extension of the revetments above and below Bee Creek as fast as the proposed shore line between them is reached, and the extension of the upper revetment to the bluffs. It also includes the closing of the chute behind Leavenworth Bar.

Attention can now be given to some of the improvements which are not immediately required for safety, such as the narrowing of the stream until the most advantageous cross-section is obtained, and the raising of shore bars above the plane of overflow. This should especially be done in the large bend above the fort and from the bridge to the north line of Leavenworth City. The agencies to be at first employed for this purpose are brush fences, and after portions of the bar have been raised above overflow willows should be planted at every point where their growth is possible. Brush fences put in late in the fall should be made of willow, as they may accumulate sufficient earth before spring to allow the willows to grow.

Attention must soon be paid to the condition of the river above Weston. The right bank, throughout the crossing from Kickapoo Station to Weston, is being rapidly cut away, and changes are taking place which must sooner or later affect the work below. Owing to incompleteness of surveys, the necessary work cannot be outlined at present, but the closing of one of the channels passing the Weston Island should be included in the plan of improvement. Should the Kansas channel be closed, the right bank of the river in the vicinity of Kickapoo Slough would need protecting.

During the past season brush has been economized to quite an extent by a reduction in the thickness of mats, but the saving has not been as much as was expected, on account of the greater compactness of the thin mattresses. As there seems to be no case yet known where failure has resulted from scour through a well-constructed mattress, the thickness may still be reduced with safety, and the brush more openly laid.

In the accompanying financial statement the price of stone given is that of total cost delivered where used. None was purchased during the season, as there was more than a sufficient quantity on hand. There was no expense for brush, except for cutting and delivering. That used on the Bee Creek revetment was hauled a distance of 4½ or 5 miles.

The tabulated results of soundings made in 1879, slope measurements of 1878 and 1879, and discharge measurements of 1878 are respectfully submitted with this report.

I have been ably assisted in prosecuting the work of the past season by Assistant Engineers G. T. Nellis and A. P. Dyke; Mr. Nellis being in charge of construction works and all pertaining thereto, and Mr. Dyke in charge of surveys.

I have the honor, major, to be, very respectfully, your obedient servant,

D. W. CHURCH,
Assistant Engineer.

CHARLES R. SUTER,
Major of Engineers, U. S. A.

Q 8.

IMPROVEMENT OF MISSOURI RIVER AT ATCHISON, KANSAS.

Work at this locality was confined to repairs of old work, and to extending up stream the revetment of the left bank of the river above Atchison. Of this new work 2,572 feet was completed, and is now in fair condition. During the present season it is proposed to continue

this work. Assistant D. W. Church had charge of the work, with Assistant G. E. Fritcher in local charge.

Interesting details concerning the method of mattress construction used will be found in Assistant Church's report herewith appended.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$17,590 74	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$37,590 74
July 1, 1880, amount expended during fiscal year		17,586 32
July 1, 1880, amount available		20,004 42
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		60,000 00

REPORT OF MR. D. W. CHURCH, ASSISTANT ENGINEER.

ATCHISON, KANS., *July* 20, 1880.

MAJOR: I have the honor to submit the following report of the work of improving the Missouri River at Atchison, Kans., during the fiscal year ending June 30, 1880.

A map of the reach and other drawings pertaining to this report have already been informally submitted. A drawing of mattress-boat and four photographic views thereof are herewith submitted.

The season's operations were confined to the construction of revetment at McQueen's Bend, the object being to hold the deeper portion of the bend and allow the point at its lower end to recede.

Two thousand five hundred and seventy-two linear feet of mattress work were put in, of which 812 feet were continuous, and 1,760 feet were made in separate mats extending 60 feet along shore.

The latter was in process of construction at the beginning of the year, and with the exception of 490 feet of repairs, which will be hereinafter described, was all made according to the method then in use, for a description of which I beg to refer you to my report for the fiscal year ending June 30, 1879.

From July 1 to 15 there was a constant caving of the bank in the vicinity of the ways, rendering frequent repairs necessary and greatly retarding the work.

On the night of July 15 there was a severe wind storm, which drove the waves directly against the shore. No upper-bank protection had been put up to that time, and the stage of the river was such that the mats did not extend above the water's edge. There was, therefore, very little to resist surface action, and the waves washing over the mats caved the bank inside.

The shore portion of the revetment was settled by the weight of the bank that caved upon it, and no longer protected the shore from current action, which, together with the waves, carried the shore line back about 15 feet throughout the whole extent of the work.

The ways were almost entirely destroyed, and consequently the revetment could not be immediately repaired.

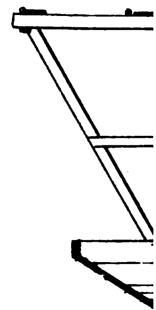
By the time temporary ways were finished the inshore edge of the revetment was from 25 to 35 feet from shore. This intervening space was covered with mattresses which varied in width from 40 to 48 feet according to the width of unprotected bank, thus providing for a lap of at least 10 feet on the former work.

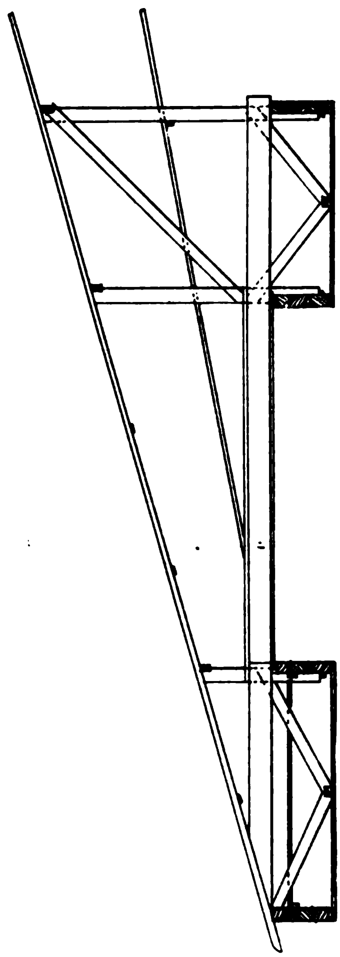
These mattresses were made similar to those used on the Leavenworth improvements during the winter of 1878–'79, the lower frame being of cotton-wood poles and the upper of fascines with wire bindings at every intersection. The thickness when bound was from 10 to 12 inches, and length along shore 60 feet. The work of protecting the high-water bank followed the mattress work as closely as possible. The form of mat used for this purpose was exactly similar to the low-water work, with the exception that fascines instead of poles were used to give the necessary strength in a direction perpendicular to the shore line. The upper-bank protection overlapped the low-water work about 6 feet, and was weighted with stone along the lap. The re-

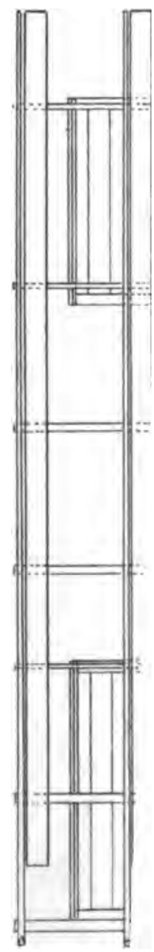
U.S. Engineer Office,
St. Louis, Mo. September 10th 1880.

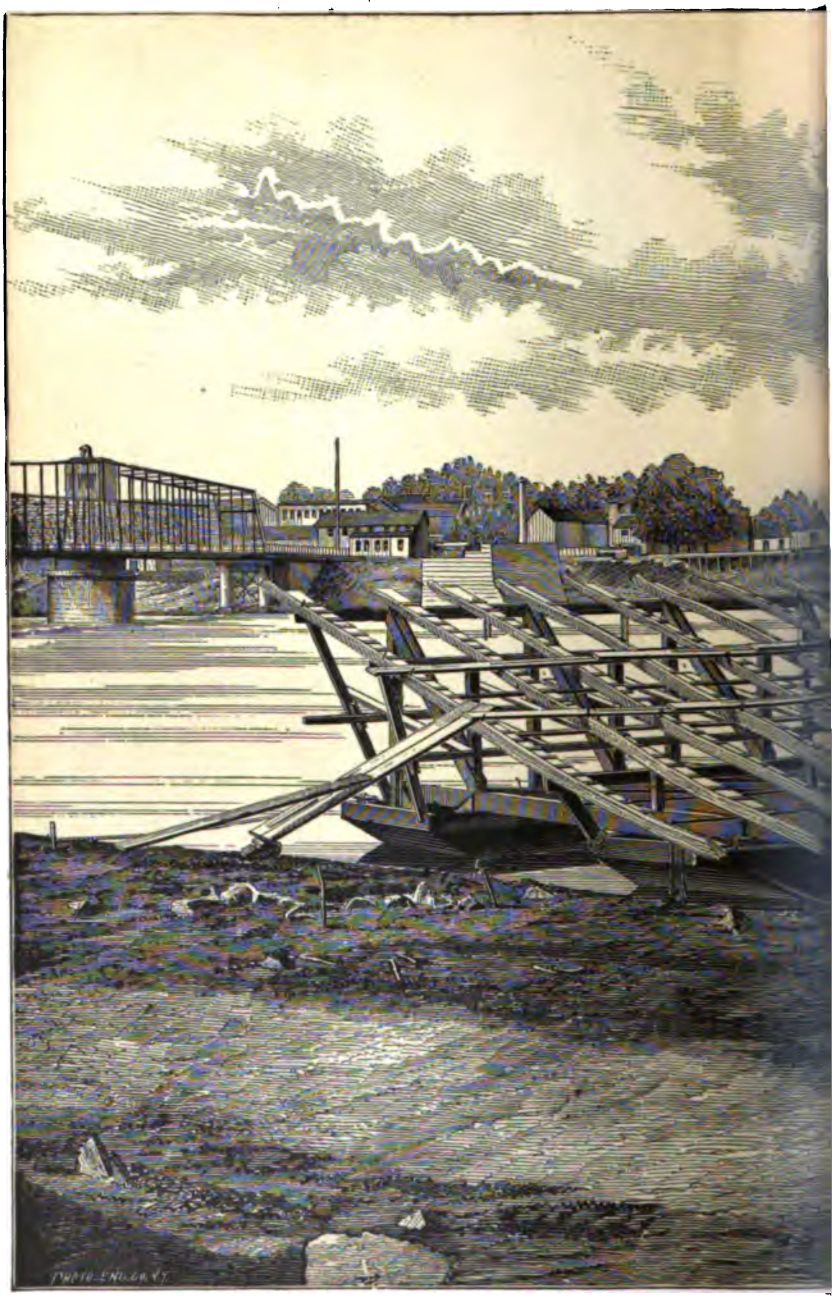
Sent to the Chief of Engineers with annual report for 1880.

Chas. R. Suter
Maj. of Engrs. U.S.A.



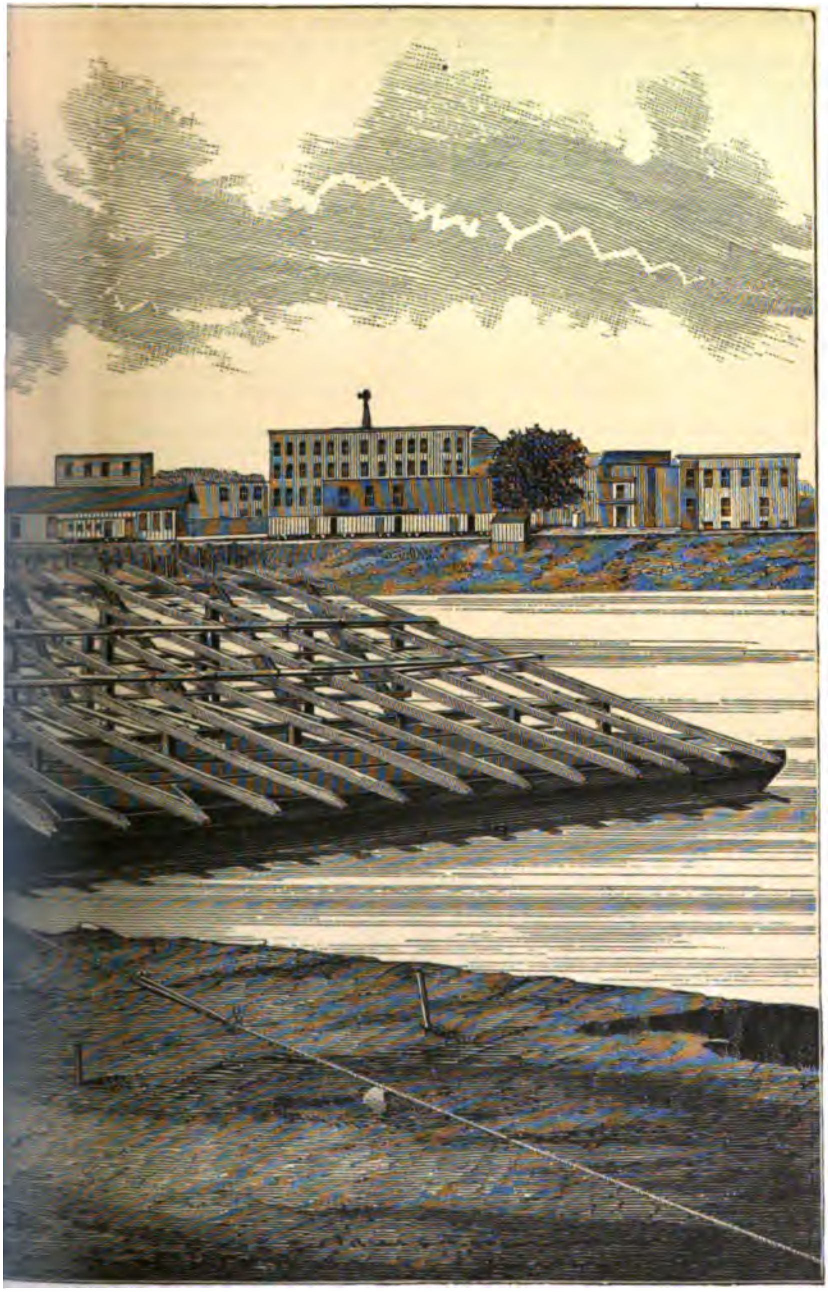






IMPROVEMENT OF THE M

McQUEEN'S BEND REVETMENT. CONTINUOUS



I RIVER—ATCHISON, KANS.

MATTRESS—FRONT VIEW OF MATTRESS BOAT.

mainder was held down by stakes driven from 3 to 7 feet in the ground and wired to the fascines. These repairs extended over 490 linear feet of shore.

The continued caving of the banks in the vicinity of the work pointed out the fact that there was no point within suitable distance where ways could with certainty be maintained, and the construction of some form of boat upon which mats could be made without the interference of caving banks became a necessity. A plan for a boat was immediately submitted to you, and received your approval. The construction of this boat—a description of which will appear farther on—was proceeded with at once.

The safety of the work already in demanded that operations be continued until the boat was ready for use, or at least until there should be less caving above the revetment. Therefore, after the work washed out by the storm had been replaced, the revetment was continued from elevated ways the same as at first, and the upper bank protection carried along with it.

On September 5 there had been put in 1,760 linear feet of revetment, and it was then thought safe to stop the work until the boat was ready for use.

The cost of this work was for low-water revetment 2.26\frac{98}{100}$; for grading bank, $0.31; and for high-water revetment 0.37\frac{3}{10}$ per linear foot; that done previous to July 1 is not considered, as it was necessary to put in new mats throughout when the washout occurred.

The mattress-boat consisted of two barges placed parallel with each other and connected by a rigid frame-work which supported the ways. The distance between the two adjacent gunwales was 16 feet and 9 inches. When in use the barges were perpendicular to the current, the ways rising from the up-stream gunwale at an angle of 16¼ degrees with the horizontal. The barge at the foot of the ways was 12 feet wide and the other 10 feet, the length of each being 75 feet, and the depth 3 feet. The way pieces were 5 feet apart and 16 in number, making a total width of 75 feet. Six lines 10 feet apart passing over pullies at the head of the ways were used in holding the mat to the boat. The cost of the mattress-boat complete was $1,121.79.

In constructing the continuous mattress the boat was placed perpendicular to the shore at the head of the proposed revetment with the foot of the ways up stream. As the mattress work proceeded the boat was moved from under it down stream, the current sinking the mat as it was slid from the boat.

The brush was laid directly on the ways with tops toward the center of the stream. At first the space between the two way poles farthest from shore was covered with brush; the next space was then covered, and a good lap made on the brush first laid. This was continued until the ways were completely covered. There was a lapping of the brush, therefore, at every way-pole. In binding, a seam which included all the overlapping brush was sewed along each way-pole. The stitch used in sewing was not a perfect lock-stitch, but was such that no loosening of the brush would occur farther than one stitch away from the point where a wire was broken. Two shuttles were used in making it, there being a wire both over and under the brush. The length of stitch was about 30 inches. The shuttles were put through the mat from opposite sides at the same time, and about 8 inches apart, so that a quantity of brush might be included between the wires. As the point of each shuttle appeared through the mat the wire attached to the other was placed over it and the shuttles pulled through. No. 12 wire was used at first, but as it broke occasionally when drawn too tight it was found necessary to use No. 10 instead, after which no wires were broken.

The six lines on the boat were always attached to the mat, except when their fastenings were being changed from the foot to the head of the ways, at which time auxiliary lines were used to prevent the current from drawing the mat from the ways. The boat was held in position by lines which extended from its outer end to the shore both above and below. At each time of moving 32 linear feet of mattress were slid from the boat, and about 8 were left on the ways. On account of friction against the bank it was usually necessary to employ a tackle in moving the boat. To provide against the possibility of the mattress being rolled up by the current it was well weighted with stone at its up-stream end, and over the remainder of the revetment there was distributed about 9 cubic yards of stone for 100 linear feet. The mattress thus made was 6 inches thick when bound and 75 feet wide. It extended above the water line about 4 feet. Great flexibility was secured in all directions, and the mattress was compact and strong. Only 812 linear feet of this form of protection was made before the work closed for the season. The cost was 1.72\frac{11}{100}$ per linear foot. This piece can hardly be taken as a fair test of the method. The short duration of the work did not allow of the adoption of certain improvements in the boat which were seen to be advisable, or of the careful systemization of the labor.

Unusual difficulties were also encountered in procuring supplies. During the twenty-seven days that the work was in progress there were only sixteen in which the roads were at all passable, and the greater part of that time only partial loads of brush could be hauled. This irregularity in the supply of brush greatly increased the cost of the work. The upper-bank protection along the continuous mattress was made

like the woven revetment constructed by assistant Samuel H. Yonge at Vermillion, Dak. It was woven into the low-water revetment, and extended up the bank to high-water mark. The cost per linear foot was 34$\frac{8}{10}$ cents. The grading of the bank cost 28$\frac{4}{10}$ cents per linear foot.

Funds were not available at the close of the work for making a root, and as a partial substitute the bank was graded very flat for a distance of about 100 feet at the head of the revetment, and the high-water protection carried to the top of the grade. This part of the woven work was strengthened by sewing with wire. Stone was distributed over the surface and wired to the brush.

During a slight rise in the river in November, 1879, a break appeared in the revetment near the upper end of the 490 feet washed out July 15. About 300 feet of the repaired work was soon taken in, and the bank then remained stable until the April rise of 1880, when the break was again enlarged. This break occurring at a comparatively low stage of the river indicated that there was a serious imperfection in the revetment. An examination showed that there was an opening between the mattresses washed out in July and the one placed between them and the shore. It is probable that after the washout in July the low-water bank did not immediately take a natural slope, as the material under the mats was not entirely removed.

The tendency to form a natural slope after the narrow mats were placed probably slid the outer mats, and thus caused the opening. Owing to lack of funds nothing has been done to repair this break, and it now extends over about 900 feet of shore.

The surveys of the season consisted of shore line location, and of slope and cross-section measurements. Sections 1,000 feet apart extending over the reach from △ 661 to △ 679, a distance of 7 miles, were twice sounded. The slope throughout the same distance was taken at points 2,000 feet apart at the time of sounding sections. A shore survey was made in August at McQueen's Bend to determine the proper down-stream limit for the revetment, and in October a complete low-water survey was made extending over the whole reach covered by slope measurement.

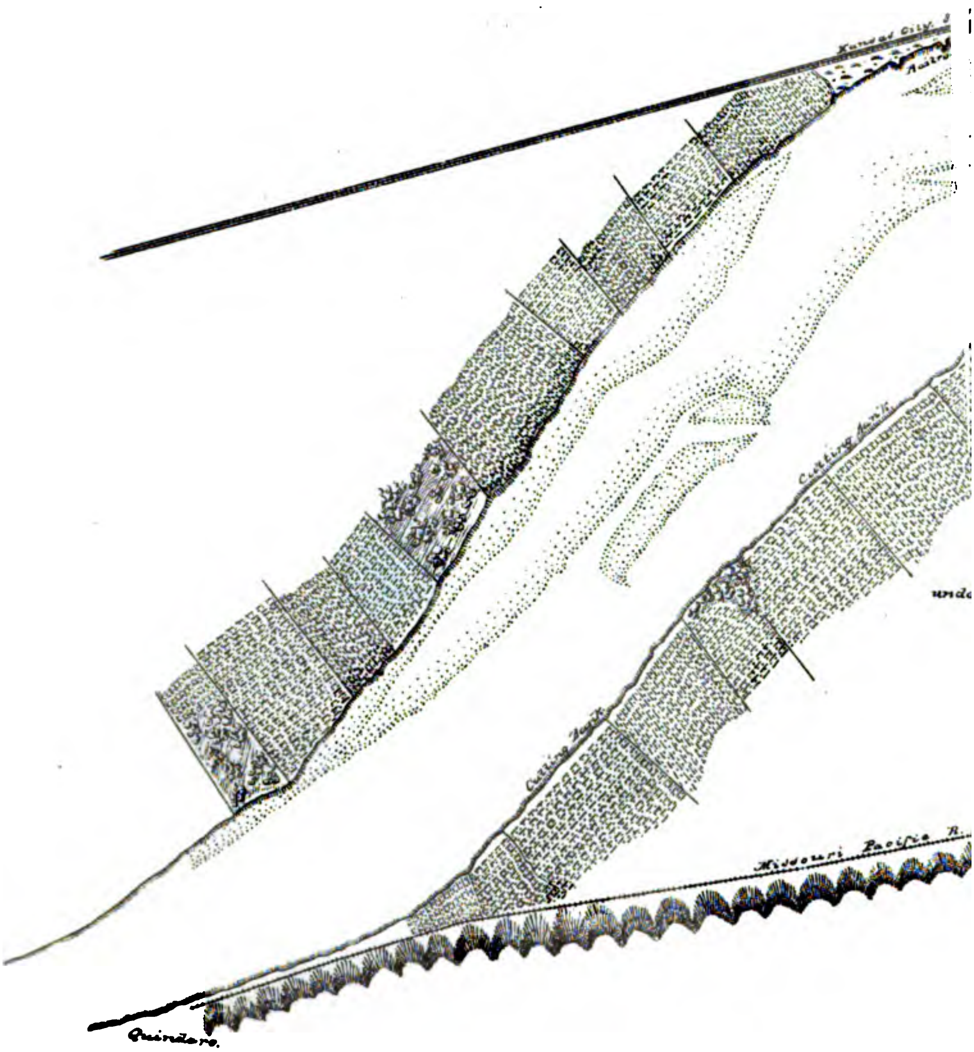
The map referred to in this report was made from the notes of the August and October surveys in connection with those taken by the Missouri River survey party. On this map are platted the centers of figures of low-water cross-section areas, those of the same survey being connected by dotted lines. It will be seen from these lines that since the surveys of 1878 the channel immediately below McQueen's Bend has left the Missouri shore and made a crossing to the right bank. In its return to the left bank the channel approaches the revetment of 1878 about 2,000 feet below its upper end. This return crossing moves down stream as the island on the right bank is cut away, and at the present date the shore line has receded far enough to allow a considerable percentage of the stream to follow the right bank until after passing the bridge. This change of channel is of the greatest importance, as it bids fair to effect within a year the desired rectification of channel at and above the bridge. Where the change of channel is greatest the slope of the river has been increased since 1878, and as this is probably due to the energy expended in excavating the new bed it may be argued that after the complete rectification is made and further changes are prevented, there will be an equal if not a greater decrease in slope.

In January, 1880, a continuous bar extended from directly below McQueen's Bend to about 1,000 feet below the head of the 1878 revetment, and after the present high water is past it will undoubtedly be much larger. This bar should be built up and extended by means of sand fences and dikes, in order that the natural tendencies may be aided as much as possible. Owing to the break at McQueen's Bend and the erosion above the revetment any discussion of future operations is thought to be useless, as all consideration of the subject must be based on the condition in which the shore line is left by the present high-water. It is thought, however, that on account of the favorable changes now taking place above the bridge the plan heretofore followed should be adhered to if possible.

In future operations with the mattress-boat, I would respectfully recommend that the ways be extended at the shore end of the boat by means of a jointed platform, so that the mattress may be made continuous to the top of the bank. The connections with the boat should be sufficiently strong to allow of a tackle being attached to the extreme shore end of the platform and a horse employed in moving the boat. The walking planks on the ways should be placed lower than they have been thus far, to avoid any friction of the brush against them.

The brush used on the work was principally dogwood; 797¼ cords were purchased, delivered on the river bank at 85 cents per cord.

After boating a distance of two miles it cost, delivered at the works, $1.16¼ per cord; 1,476 cords were cut and delivered by hired labor, there being no expense for the standing brush; it was hauled a distance of 6 miles and cost $1.26 per cord; 77¼ cords of willow brush were used on upper-bank protection; it was procured from various sources, the cost of cutting and delivering being $1.54 per cord. The stone was taken from that purchased in 1878 and not expended. The price given in the



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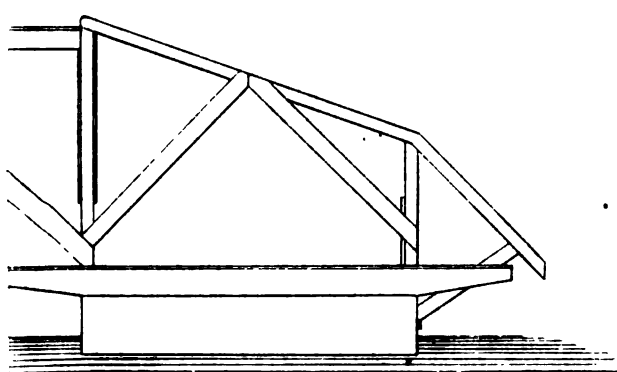

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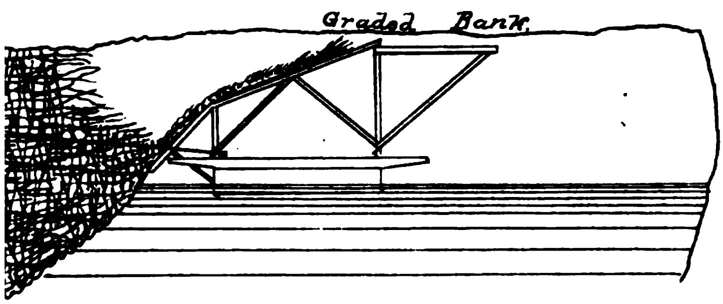


Section of

Mattressed Bank.

with deepest water.

Scale 1/16" = 1'.

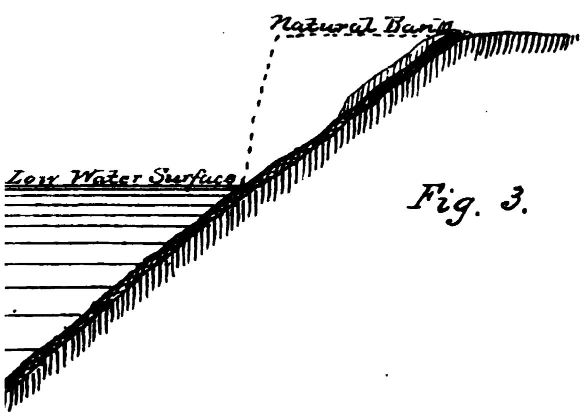


Fig. 3.

following financial statement is the original cost added to the cost of delivery at the revetment.

Tables of the slope an section measurements made in 1878, under the supervision of Assistant C. B. Davis, and those made in 1879, are respectfully submitted with this report.

I am indebted to Capt. D. W. Wellman, assistant engineer, for notes of Missouri River survey extending over that postion of the reach between △ 638 and △ 660; the latter point being the upstream limit of surveys made in connection with the work.

I wish also to acknowledge the able assistance of Messrs. G. E. Fritcher and A. P. Dyke; Assistant Fritcher being in local charge of construction, and Assistant Dyke in charge of surveys.

I have the honor to be, major, very respectfully, your obedient servant,

D. W. CHURCH,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 9.

IMPROVEMENT OF THE MISSOURI RIVER OPPOSITE SAINT JOSEPH, MISSOURI.

In my last report it was stated that in continuation of the work then in progress it was proposed to cut down the old dikes opposite the city, and to revet a portion of the left bank above the railroad bridge. Attention was also called to the necessity of extending the work up stream to guard against the effects of an apprehended cut-off at Amazonia. This cut-off has since taken place, but the effects are not yet fully developed. Work was carried on in accordance with the plan proposed, and 2,000 feet of revetment successfully constructed on the left bank above the railroad bridge.

During the present season it is proposed to extend the works to the upper side of the French Bottom, to remove the old dikes, and begin the channel rectification.

All the work has stood very well. Assistant D. W. Church had charge of the work, Assistant D. F. Pruyne being in local charge.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$10,068 66	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$30,068 66
July 1, 1880, amount expended during fiscal year		8,913 05
July 1, 1880, amount available		21,155 61
Amount (estimated) required for completion of existing project		64,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		64,000 00

REPORT OF MR. D. W. CHURCH, ASSISTANT ENGINEER.

ATCHISON, KANS., *August* 2, 1880.

MAJOR: I have the honor to submit the following report on the work carried on under my charge in the vicinity of Saint Joseph, Mo., during the fiscal year ending June 30, 1880.

The water front of the city of Saint Joseph has been subject to erosion from time to time throughout its whole extent, and large sums of money have been expended

by the Kansas City, Saint Joseph and Council Bluff Railroad Company in works of protection. This protection, which consisted of short spur-dikes together with a heavy riprap on the intervening bank, extended to within 2,024 feet of the east abutment of the Saint Joseph bridge. The latter section of shore was receding each year, and it was proposed in the place of the season's operations to protect it with a brush revetment.

The banks at low-water are about 25 feet high, and composed of very hard clay. It was learned, from borings previously made in the vicinity, that this clay extends about 16 feet below low-water. It is underlaid by 8 feet of quicksand, below which there is clay, sand, gravel, and bowlders to bed-rock. The clay of the upper stratum is sufficiently tenacious to almost entirely resist the action of flowing water at any velocity acquired by the Missouri River, and in itself required no protection; it was only necessary to prevent the scouring out of the quicksand layer.

As a result of soundings the width of revetment decided upon was 70 feet, measuring from the water's edge, no high-water revetment being deemed necessary.

Local obstructions along shore were such as to interfere with making the revetment in sections on the bank and floating it to place, and the other usual alternative, that of constructing it on a boat, could not well be adopted as there was neither a suitable boat on the work or money which could be spared for building one; as a substitute a floating platform was devised, the cost of which was about the same as a set of fixed ways on shore, and which could be used in the same manner as a boat for constructing a continuous mattress.

The form of revetment adopted was the woven mat, introduced by Samuel H. Yonge, assistant engineer at Vermillion, Dak., and the float was designed for that purpose. Its use is not, however, restricted to that particular method. A drawing of the float as finally used accompanies this report. It was 60 feet long and 12 feet and 8 inches wide. Ranged across under the platform every 5 feet were box floats, 12 in all, the cross-section of each being 1 square foot and the length 12 feet and 4 inches. The boxes were made of 2-inch pine plank, and on top of each there was an extra plank to prevent the spikes from the platform from reaching the inside of the box and thereby causing a leak. In the joints a strip of flannel was laid in white lead, and the whole thoroughly tarred after nailing. Besides the bracing afforded by the close platform spiked on the top of the boxes, there was a continuous stretch of plank nailed to their ends and diagonal braces underneath. On the platform and directly over each box a plank 1 foot wide and 12 feet long was set upon edge and braced by spiking a 6-inch angle piece on each side. These planks served as ways. They projected over the edge of the float 2 feet, and on the projecting end were rounded down to a height of 5 inches. Four cleats were bolted to the platform for use in attaching the lines.

The float was used in the same manner as the various boats which have been employed in constructing continuous revetment.

Before any portion of the mat had been made to break the current the pressure against the float was so great that it could not be held with safety perpendicular to the shore. Therefore, in starting, the float was placed along shore, and the mat built out towards the center of the stream until a width of 70 feet was reached. Weaving was then commenced on the down-stream side of the mat, with the float in its proper position, perpendicular to the shore. The brush used being willow, the mat was sufficiently buoyant to support the men carrying brush, and none except the weavers and their helpers were on the platform.

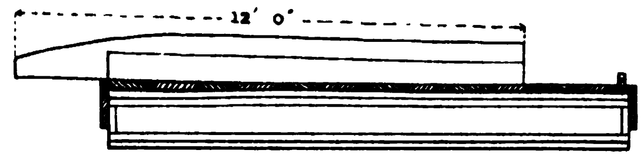
The up-stream edge of the platform was tipped below the water as the mattress was woven into it, and to prevent the current from partially sinking and turning the float a line was attached to the up-stream outer corner and from thence over the mat to the shore above. The place occupied by the weaver was always above water, and the tipping of the platform was of advantage in moving the float.

For the purpose of strengthening the mat and securing it to the float 2 lines ¾ of an inch in diameter were woven into it, one near the outer edge and the other 16 feet from shore. A windlass on shore was employed in moving the float from under the mat. The progress per day was at first but about 40 feet, and to hasten the work a second float was made, and another gang of weavers employed as soon as the first was in successful operation. This float was placed about midway of the unprotected shore, and used to construct the mattress from that point to the bridge.

The revetment crossed the mouths of two creeks, which at times of heavy rainfall discharge large quantities of water into the Missouri. The work was carried a short distance up the beds of these streams and well weighted with rock. For sinking the mat 11 cubic yards of rock (about 14 tons) were used per 100 linear feet.

The work was completed to the bridge November 27. Its cost per linear foot was $1.67. The greatest item of cost is the weaving, and therefore for cheapness in this form of revetment it is requisite that the labor employed be skilled in the work. With the exception of one man, the workmen employed at this point were without previous practice.

The float system is believed to be advantageous where the amount of work to be



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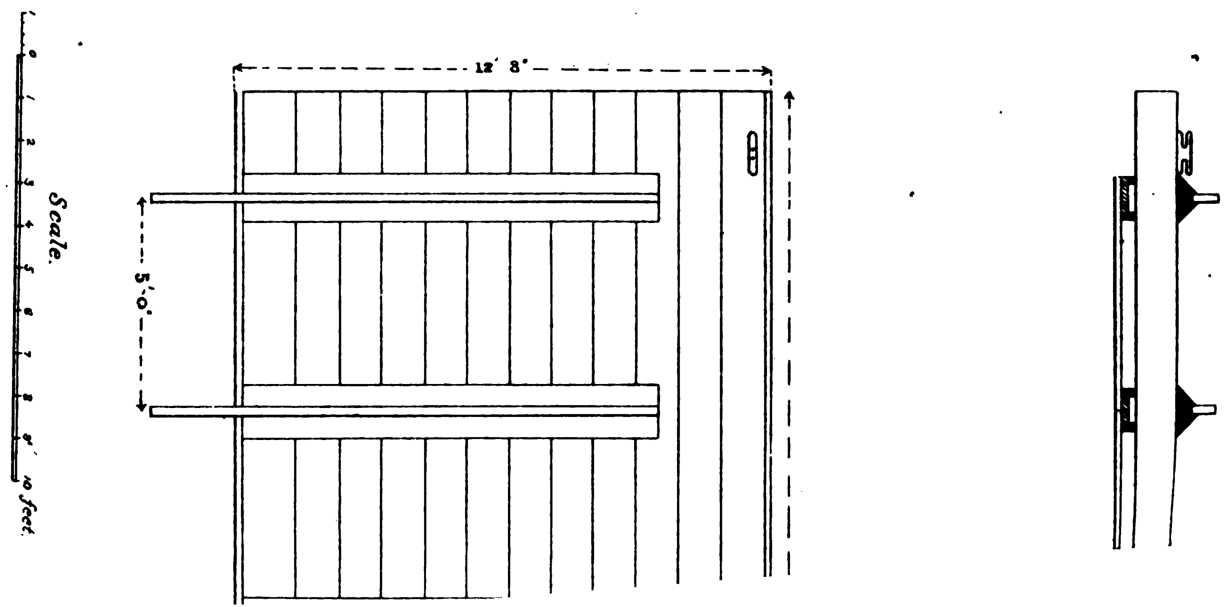


done will not fully warrant the construction of a boat. There may be localities on the Missouri River where the strength of the current would forbid its use, but such is not generally the case. It is essential that willow or other brush of small specific gravity be used. The chief advantages of the float are it cheapness, the small cost of lengthening it for constructing a greater width of revetment, and the ease with which it is moved from under the mat.

After the completion of the revetment, and at a time when the ground was saturated by a heavy rainfall, it was noticed that portions of the upper bank had settled, without any apparent movement of the revetment. It was evident that the action took place entirely from above the water, as that part of the mattress which was on the bank was partially folded by the pressure of earth against its edge. The water which oozed from the bank kept it in a plastic state, and the clay seemed to have flowed down on account of the steepness of the slope. The work received no injury from this cause.

During the April rise of 1880 the shore end of the mat was torn in several places by the current, there being an insufficiency of stone on the part exposed during low-water. No portion of the work was carried away, and all damage was repaired by placing more stone along the broken edge.

Slight repairs were made at dike No. 3, on the Kansas shore, in July, 1879, and in May, 1880, 3 small mattresses were put in immediately above dike No. 2, to repair a break which threatened the destruction of the dike at high-water. The brush used on all work of the season was willow. It was purchased in various localities at prices ranging from 10 to 25 cents per load for the standing brush. The stone was purchased, delivered at the work, for 95 cents per cubic yard.

The principal surveys of the season were made with a view to observing the effect of the cut-off which took place near Amazonia, Mo., July 22, 1880. These surveys will be reported upon as soon as others have been made to note the changes.

In November a low-water survey was started at the bridge and carried to a point 4 miles above. It then become necessary to discharge the party in order that work on the revetment might not be crippled through lack of funds. The accompanying map is made from the notes of the Missouri River survey. The low-water survey is platted thereon, and throughout its extent the shore lines of the general survey are dotted.

Since June 23, the date of my letter to you proposing a plan for the expenditure of the present appropriation and containing estimates for the future, no surveys have been made, and consequently a more definite discussion of future operations than is contained in the letter referred to cannot yet be had.

I wish here to acknowledge my indebtedness to Mr. D. W. Wellman, assistant engineer, for the use of notes of the Missouri River survey.

The works of construction at this point were under the local charge of Assistant D. F. Pruyne.

I am, major, very respectfully, your obedient servant,

D. W. CHURCH,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 10.

IMPROVEMENT OF MISSOURI RIVER AT BROWNVILLE, NEBRASKA.

A report upon this locality was submitted to you under date of February 7, 1880, and published as Senate Ex. Doc. No. 82, Forty-sixth Cong., second session.

By act approved June 14, 1880, a small appropriation was made for beginning this work, and will be expended during the present season in the prosecution of the plan proposed.

This work is in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	51,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	51,000 00

SPECIAL REPORT.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 7, 1880.

GENERAL: In accordance with your instructions of January 19, 1880, I beg leave to submit herewith a copy of a map of the Missouri River in the vicinity of Brownville, Nebr., made under my direction during the past season, and also a report of my assistant, Capt. Thomas H. Handbury, Corps of Engineers, U. S. A., giving the details of the situation, together with plan and estimates for a partial improvement of the river in this vicinity. The plan proposed and the estimates are approved by me. It is only deemed necessary for the present to hold the left bank opposite and above the town and the right bank below it, thus preventing further injurious changes, leaving the question of the complete rectification of the river in this vicinity for future consideration. To carry out this plan some 22,000 feet of mattress revetment will be needed, and the estimate is as follows:

For 22,000 feet of revetment, at $2.50 per foot	$55,000
Contingencies, &c	6,000
Total	61,000

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPT. THOMAS H. HANDBURY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 6, 1880.

MAJOR: In obedience to your recent verbal instructions to prepare and submit a plan and estimate for the improvement of the Missouri River in the vicinity of Brownville, Nebr., I have the honor to submit the following:

After a careful study of the map of the Missouri River in this vicinity recently made by your assistant, D. W. Wellman, and of others of older date, and from conversation with those who are familiar with the locality, I find that for several years past the river has been eroding the right bank in front of and below the town, and the left bank just opposite and in the bend above, to such an extent as to materially widen the bed and decrease the depth of the navigable water-way. It is evident that if these erosions are not checked, the navigation of the river in this vicinity will be seriously impaired. Brownville is a point of considerable importance as a crossing of the Missouri River. The ferry facilities for crossing the emigrants, stock, grain, and produce of all kinds that center here have heretofore been very good, but there is great danger that if the erosion of the point at which the eastern landing is made continues much farther, shoals and bars will be formed in the widened bed of the river that will render long detours necessary, and perhaps break up the ferry entirely.

By the expenditure now of a very reasonable amount of money these erosions can be stopped, whereas if the matter is deferred until a later day, great detriment to navigation will result, the ultimate expense of remedying which will be very much increased.

For the present, I would recommend that the left bank be revetted from the ferry landing up for a distance of 5,000 feet. It might be well also to make provision for extending this some 10,000 feet farther, in case the main channel of the river should fall against the concave side of Rockport Bend. I would also revet the right bank from about the ferry landing down for a distance of 7,000 feet. This I deem to be necessary in order to prevent further widening of the river bed, and to preserve much valuable land from being washed away. This will make about 22,000 feet of bank to be revetted.

I say for the present I would recommend this to be done, but I do not regard this as the ultimate solution of the problem. The true remedy, in my opinion, is to restore the shore line of the left bank to something like what it was before the recent excessive

erosions began, and then to revet the banks on both sides of the river for some distance above and below the town. This part of the improvement I do not deem it necessary to commence at present. Its consideration will naturally come up when the problem for improving the general navigation of the river is under discussion.

Upon the accompanying map I have indicated the portion of the banks that I think it expedient to revet as soon as funds can be made available. The revetment that I would propose for adoption here would be some form such as has been used with success during last season at the several localities along the river where works of improvement were carried on under your directions, and such as was recommended in my report to you, dated January 28, 1880, on the improvement of the Missouri River between Omaha and Plattsmouth.

I estimate that in this locality the revetment can be made for $2.50 per running foot of bank.

At this rate, the estimate for that which I deem necessary to be done under the present project will be as follows:

For 22,000 feet of brush revetment, at $2.50 per foot	$55,000
Superintendence, contingencies, &c	6,000
	61,000

Respectfully submitted.

Your obedient servant,

THOS. H. HANDBURY,
Captain, Corps of Engineers.

Maj. C. R. SUTER,
Corps of Engineers, U. S. A.

Q 11.

IMPROVEMENT OF MISSOURI RIVER AT EASTPORT, IOWA, AND AT NEBRASKA CITY, NEBRASKA.

At the date of my last report work was in progress at this locality, mainly directed to saving the work of the previous year. This was at length accomplished, but at the expense of a large portion of the appropriation. Work was then begun on the works of channel rectification, and some very excellent methods of construction for this class of works were devised. The season for favorable work had, however, passed by, and lack of funds prevented the works from receiving the proper extension. The same remark applies to the new revetment work constructed, much of which was destroyed by the floods of this season owing solely to the reason that it was incomplete. These facts are the more discouraging as there is little doubt, from the temporary success achieved, that a sufficient amount of available funds would have enabled us to accomplish the objects proposed. The appropriation for this year is smaller than ever and will accomplish little, and it cannot be too strongly urged that if the ruinous system of small annual appropriations, entirely incommensurate with the estimates, is to be kept up for these works on the Missouri River, there is no telling how much they will eventually cost nor whether they can ever be completed.

During the season, in addition to the repairs on old work, there was constructed 2,000 feet of revetment, 1,200 feet of sand fence, 3,000 feet of willow curtain dike, and 1,000 feet of wire curtain dike. These latter constructions are novel and interesting; they are fully described in the appended report of Assistant L. E. Cooley, who had charge of the work.

During the present season the various works of bank protection and channel rectification will be extended as far as the funds available will allow.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$28,055 15	
Amount appropriated by act approved June 14, 1880	14,000 00	
		$42,055 15
July 1, 1880, amount expended during fiscal year		27,436 95
July 1, 1880, amount available		14,618 20
Amount (estimated) required for completion of existing project		41,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		41,000 00

REPORT OF MR. L. E. COOLEY, ASSISTANT ENGINEER.

NEBRASKA CITY, NEBR., *July* 26, 1880.

MAJOR: I have the honor to submit the following report of operations at Nebraska City and vicinity during the fiscal year ending June 30, 1880. These operations were conducted in general accordance with the preliminary project of July 14, 1879, which contemplates the ultimate rectification of the river from the vicinity of Jones' Point to Nebraska City, a distance of some 15 miles. The experience of the past two years has confirmed the idea of the original project that any improvement which accomplishes the objects desired at this point implies the complete control of a considerable reach of river. At the present writing it is believed, if permanence be at all considered, that it is not only wisest but cheapest to commence above the place to be affected at some permanent nodal point where easy control of the direction of the stream may be had, working thence down stream. Works are then placed on the sites of causes rather than on the sites of effects, and control forces which cannot be directly resisted except at great and uncertain expense; successful works may be outflanked by the uncontrolled river of succeeding years.

The vital nature of certain points to be protected, combined with omnipresent local interests, frequently demand works on the sites of effects, and it is too often the case that more money is expended in constructions of doubtful stability than would be required for complete rectification and reasonable permanence.

The absolute necessity of holding Eastport Point at all hazards demanded the construction of works of protection at that place in 1873. The changes which occurred in the spring of 1879 (fully described in report of last year) proved these works to be inadequate, and in the fight which took place against water 60 feet deep running at 8 miles per hour, although ultimately successful, a larger portion of the appropriation was expended, leaving but a limited amount for the scheme of permanent rectification Could all the funds have been devoted to that object it is believed the project would now be well advanced towards completion.

The balance available was expended in making borings, in surveys, and in construction. The nature of strata underlying banks that cut at the rate of a thousand or more feet per year and what obstructions, if any, to a projected shore line might exist beneath the surface of the bottom, were regarded as questions of paramount practical importance as well as of much scientific interest. The results of the 38 borings made to permanent strata by Assistant E. N. Wilson are presented in his report to you.

Much physical data has been collected at odd times by the party engaged for the most part in studying the effects of the works of construction, but as their labors were prematurely cut short by the orders of October 16, 1879, the discussion of the results is deferred until opportunity is furnished to make the data more adequate.

The works of construction consisted of about 1,000 feet of revetment below the mouth of Walnut Creek at the foot of Copeland's Bend, and another thousand below Lambert's orchard in Civil Bend; of a curtain dike above Neligh's, and a second nearly opposite the old dike of 1877, designed as part of the works to direct the river in the desired course through Copeland's Bend; of a sand fence opposite Neligh's for the purpose of building up the bar; and of a surface mat in Eastport Bend for the purpose of preventing the advance of the pocket around the bend and the flanking of the works below.

Some description of the changes of the river in this reach is necessary to a proper understanding of the object of these works and of their results.

The point to which much change has been apparently due, in part at least, is about 3 miles above Jones' Point and is called Pin Hook. This is a sharp irregularity in the bluff, projecting to one-half the width of the normal river. To Jones' Point below, the shore line has a curvature of about 40 degrees.

A slight change in the vicinity of Pin Hook will cause the river to leave the shore-line below and follow the chord of the curve, as it does follow the curve on this chord

in its course to the eastward or the westward of the large middle bar below Jones' Point. This bar is on the site of old Hurricane Island.

When the river ran to the westward of the bar it impinged heavily on the shore of Civil Bend at Lambert's Orchard, and excavated there a large pocket, striking the bluff high above Wyoming Landing. This seems to have been the case at the time of the first survey in 1876 and 1877. By 1878 the river had shifted to the eastward of the bar, and the place of erosion had been transferred to the point below the pocket. Every indication seemed to make it probable that the river would hold to this course for several years, or until the project below could be consummated, when this portion could be given proper attention.

The project was to revet the pocket and allow the point to cut away, extending the protection down as fast as the new shore developed to a fair line. The cutting away of this point would allow of the desired course through Copeland's Bend free from contact with the Wyoming Bluffs. According as the river had met these bluffs was it to a certain extent influenced in its wanderings below.

Up to about July 5, 1879, the river continued to the east of the bar below Jones' Point. The point of land and the bar opposite Wyoming cut away rapidly, and the bluff contact nearly disappeared at Neligh's. The changes below were most marked, and the river seemed in fair way to accomplish fully the object desired—a fortunate circumstance, as all energies were then concentrated in the bare task of holding Eastport Point.

Between the 5th and the 15th of July, the channel shifted to the westward of the bar below Jones' Point and struck heavily against the revetment in Civil Bend. The bluff contact at Wyoming moved rapidly up stream, and the advantage gained below in Copeland's Bend seemed likely to be lost. As soon as the forces could be withdrawn from Eastport Point, a dike of willow curtains was constructed above Neligh's on such a line as would preserve the direction in which the river ran while it was accomplishing the changes below, and prevent it from striking the bluffs and returning to its old course. This plan succeeded beyond our most sanguine expectations, but ere the results could be secured the appropriation was exhausted.

Meantime a second dike was constructed below from the bar side on left bank, designed to increase the width of accretion and possibly to force the water down the chute. This dike failed to force the water in the chute, but otherwise was an ample success.

The unanticipated change below Jones' Point altered materially the problem in Civil Bend. Revetment originally designed to resist erosion from nearly tangential flow was now subject to direct impact. This revetment was of the same width as that originally designed for Eastport Point, and like it, under similar conditions, it failed, and for a length of 1,000 feet. The success at Wyoming led us to believe that the project could be still carried out, and accordingly a very strong, continuous mattress, 100 feet wide, was laid down on modified lines in place of that which had been found inadequate. The design was to extend it either way as the shore cut to a fair line.

MATTRESS WORK.

The mattress work on Eastport Point was not completed at the end of the last fiscal year. The surface portion was everywhere widened sufficiently to provide for scour to rock and covered with earth as a protection against sun and air. Part of this surface portion was constructed on the system of woven mattress work described in Assistant Yonge's report to you for 1879. By the end of July the pocket, which had cut from the head of Eastport Bend and attained a depth of 1,300 feet, was within three-quarters of a mile of the revetment. It was thought that a very strong surface mat placed at the point of the pocket might stop its progress around the bend and throw the river out into the bar away from Eastport Point. The partial success of a small surface mat above the root of 1878 was auspicious.

Accordingly a mattress of an area of 31,500 square feet was woven from dogwood brush and strongly sewed with wire and heavily weighted with rock. When about one-half its width, or 80 feet, had caved into the water it began to tear or break at the edge of the bank, now 6 to 8 feet high. With additional caving the mat appeared to be entirely wrecked except a small corner. However, as the erosion at this point was decidedly checked while it continued above and the channel rapidly swung over into the bar opposite, much to the safety of Eastport Point, I am inclined to credit it with considerable influence, especially as portions of the mat were found in position as late as October.

As an experiment it simply demonstrated that a woven mat of dogwood brush well sewn with wire lacked sufficient strength for the purpose. It was thought that a more flexible mat of willow brush woven on a very strong wire netting, well weighted, would have been an unqualified success.

All of the revetment of the fall of 1879 was woven from willow brush in continuous lengths. The general width was 100 feet from top of bank, the thickness 8 to 12

inches, and from 3 to 4 pounds of rock to the square foot was used as ballast. The banks in all cases were sloped 2½ to 1. The experiment of weaving on the surface of the water without a boat failed, as the mat in a few hours so loaded up with sediment as to sink.

As the work contemplated was limited, the old mattress was temporarily adapted to the purpose. The hull was turned at right angles to the current, a curved rake placed on the upper side and needles projecting up stream on which to weave the mat. The motion of the boat was controlled by capstans and winches through lines running aft. A headline was used for the outer end of the boat. This was chiefly for safety, as the actual strain down stream was largely taken by three-eighths-inch lines woven into the mat and paid out or regulated at first by hand but afterwards by a tension apparatus. The plan of substituting wire for the three-eighths-inch rope proved unsatisfactory as the wire broke, and experiments were made with small wire rope, a crude machine for making it having been devised, but they were not concluded when the work terminated.

The progress of the weaving was much facilitated by brush-racks, which held the brush until wanted by the weavers.

The mattress work was woven with extreme care. The most rapid work was on the piece in Civil Bend, which did not exceed 75 feet per day and cost $1.96 per linear foot. The limited amount of this mat which can be made in a day and its expense are serious drawbacks. It is not believed possible to so perfect it as to exceed 100 or 150 feet per day or to reduce the cost to less than $1.50 per linear foot for a thickness of 8 inches. This thickness may be considered the limit of this style of mat for strength and rapid weaving.

CURTAIN WORK.

Curtains and wire nets as used in the place of the ordinary weed for floating dikes are constructions which we think Nebraska City can claim as entirely novel.

We believe the first dike of Brownlow weeds made in this country was constructed by Assistant Boehmer, at Nebraska City, in 1877 (fully described and illustrated in his report of 1878). Assistant Boehmer again used them at Omaha in 1878, and Assistant Davis constructed a modified form at Atchison, the same season. In various shapes they were used at all the works of improvement in 1879.

The theory of this construction was that the partial checking of the current caused a deposition of the materials transported, thus building up a bar, the channel meantime seeking a less obstructed locality.

The experience with individual weeds in 1879 was that they opposed their maximum resistance at the beginning, their size continually decreasing. This necessitated heavy anchorage and much labor in placing. The fastenings were frequently worn away by the ceaseless rotation. It was practically impossible to make them thick at the bottom where most needed and to plant them at regular intervals so that they would present a uniform resistance to the current. The result was that the bars thrown up were full of deep channelings from the thinner portions of the dike, and that the dike itself was unsupported by the growing bars from the fact that the rapid flow beneath kept the immediate vicinity free from deposits; even the anchorage was gradually undermined, causing a general settlement. If to counteract these tendencies, and also the diminishing resistance, additional weeds were applied, the dike soon began to act like a solid spur or dam with powerful eddies and silting due only to dead water or eddy action. The dike was still unsupported by its deposits usually existing on either side. In the fall of 1878, the large quantity of material, as grass, rootlets, and general débris suspended or floating in the water was first noted. In the spring of 1879 experiments were made on various forms of willow grating or screens, and these were partly illustrated and described in my report for last season. The type adopted is fully illustrated elsewhere.

The general plan of curtain used was a grating of willow brush 100′ by 33′; the design being to make them of a width equal to twice the depth of water in which they were to be placed, and of any convenient length.

These curtains were constructed as follows: On light ways No. 13 wires under slight tension were placed 4 feet apart. Across these willow brush of 1 to 2 inches diameter at the butt were laid, and then a second set of No. 13 wires immediately over the first. The upper and lower parallel wires were twisted together between each brush at spaces of 6 to 8 inches. The curtain was rolled up at the foot of the ways as completed, and the construction continued until the desired length of 100 feet was obtained, the roll being about 2½ feet in diameter. The two seams at the anchor edge were of No. 12 wire and 1 foot apart. Short No. 10 anchor wires were placed at intervals of 5 feet.

In placing these curtains two 50-foot barges, lashed end to end, were used. For moving and shifting their positions a system of four lines was found necessary. Various kinds of mooring anchors were tried, and finally a modified form of Chinese anchor was devised, which proved entirely satisfactory. Running the length of the

down-stream gunwale of each of the barges was a 2½-inch gas-pipe tumbling-beam, provided at intervals of 5 feet with iron pins, to each of which was suspended a rock of about 200 pounds weight by means of a wire bail or sling.

The curtain was unrolled behind the barges and each of the wire fastenings secured to its individual rock. Poles were usually lashed to the opposite edge and as many buoys secured thereto as desired. The two tumbling-beams were then tripped, the whole construction taking its position in the water without danger of wrecking. The barges were dropped over the curtain, and usually a half-curtain length in the direction of the dike, and the operation repeated. Thus each curtain was placed at nearly right angles to the current, while the direction of the dike itself made any desired angle.

The merit of this construction lies in its exceeding ease of launching and in its action thereafter. The resistance at first is comparatively small, but greatest near the bottom, where the curvature is flattest, and there, immediately through the curtain, fill commences, thus securing the anchorage as the first effect. In a few hours, however, the strain increases from the continued accumulations of fiber and general *débris*.

The mode of action of the current is deceptive and essentially different from that of the ordinary Brownlow weed. In the latter the ceaseless motion of the brush trailing in the direction of the current prevents the accumulation of fiber and *débris* to any extent; the resistance diminishes rather than increases, and deposition is largely accomplished through dead water or eddy action. The former fills through and is supported by its accretions with no deep water, unless its interstices are too close. It is essentially a reef builder, initiating a bar on nature's plan. The material is largely rolled in under swift currents that run wild like the currents of a falling stage on a shallow crossing that has not yet defined its channel.

It was noticed that after the accumulation of fiber on the willows had reached a certain amount it was liable to rotate or slip off, this action taking place easiest with the larger willows, while the wires of the curtain retained it better. Accordingly some experiments were made with small sections of wire net, and it was found that even on the low-water of September each wire would grow to be one-half to three-quarters of an inch in diameter in the space of 24 hours, while the net itself would be covered with a miscellaneous assortment of *débris*.

After much delay a net 200 by 40 feet was constructed and placed near the foot of the curtain dike at Wyoming, as this was the only place where a construction of this character was as that time desired. Although the water was 25 feet deep and swift for the season, it was put in without difficulty. In an hour each wire had a continuous trail of fiber, and in two hours considerable resistance was apparent. In 24 hours all the buoys had been sunk and the shore fastenings wrecked, the top of the net being but 12 to 15 feet from the bottom of the river. It filled up about 11 feet in a week's time.

The trouble lay in the fact that the meshes, which were diamond-shaped and 12 by 4 inches, were entirely too small, causing the action of a dam or solid dike rather than that of a curtain.

The experiment was, however, a crucial one as to the proper direction to be followed, plainly indicating the continuous wire net as the future dike. As the mode of construction was not sufficiently satisfactory, a plan of making a hexagonal mesh rapidly and cheaply was devised, but no opportunity of applying it was furnished.

The constructive merit of both the curtain and net is in the fastening, which is rapidly made, efficient, and reliable. It consists simply of two parallel wires under tension, twisted together by an awl inserted between them.

The first curtains were put in without buoys. The upper edge usually took a position about 4 or 5 feet from the bottom, and the fill would frequently amount to 3 feet in 24 hours, but none thereafter. This fill tended to sink the curtains or drag them down, a phenomena also observed with buoys, their tops finally reaching a level from 2 to 4 feet below that originally sustained.

The first work was decidedly experimental. The Wyoming dike was actually constructed in the last two weeks in August at a stage decreasing from 3 feet to low-water. Its location was on the reef above the trough at the bluffs, where the currents were more than ordinarily swift and tenacious of their direction. The general depth along the line increased from 12 to 25 feet, although the actual depth encountered was not over 15 feet, as partial fill preceded the construction, each curtain being placed, as it were, partly in the shadow of its predecessor.

Results developed with unexpected rapidity. In two or three weeks bars began to show themselves above the surface; not over 2 feet of water existed throughout the length of the dike, some 2,400 feet, and a considerable bar trailed from its extremity. But little effect was produced until the thread of the current leading to the trough behind was reached. Here was a steady fight for a couple of days, after which the channel line began to swing, this movement being continuous as the dike progressed.

The work below Wyoming consisted of a sand-fence, commencing about 1,200 feet above Boehmer's dike and running across the bar to the water's edge, thence a dike to

the edge of the current or about 1,200 feet from the opposite bluff, turning down stream on a line parallel to the same. The sand-fence was constructed on the plan of 1878. Across the slough, 100 feet wide near shore, a road of brush and hay had been made, and over this was placed a well braced frame-work of poles and wire, the poles being deeply driven into the mud at intervals of 5 feet; the purpose was to produce a gradual accumulation of drift and thus close this slough. The sand-fence at the bar edge was protected by a curtain partly supported on poles and inclosing its end.

In line with this fence a dike of stiff or horizontal weeds, on the plan of Assistant Nier, was extended for 300 feet until deep water was reached, and then down on the proposed line 300 feet farther. Their construction was so rapid and simple that it was hoped to build the dike with them alone as the water on this crossing was but 8 to 12 feet deep. However, when this length was reached it was found that the water began to roll over and undermine the weeds, that the deposits were some distance below, and that scour around the end prevented useful progress. In order to strengthen the work a second and again a third line of stiff weeds were placed over the constructed portions, and it was finally September 25 before they were definitely abandoned. The dike was then extended in double line of curtains 1,000 feet in two days. Buoys from the upper dike, where they were of no further benefit, were used.

The stiff or horizontal weed is an admirable construction, but its use should be limited to depths not exceeding 6 feet, in the shore or shallow ends of dikes, in closing chutes or shoal channels, and in building up low bars, being placed thereon previous to high-water.

This dike was not so successful as its predecessor. The river had already streaks of blue although considerable sand was in motion; in fact it never ceases. The mistake was made of carrying it too far across the channel, the more especially as the stiff weed portion had defeated the growth of the reef or bar out from the shore as the work progressed, as was the case in the upper dike, and should be the case in similar constructions. A considerable channel cut out around the lower end; meantime the stiff weed portion failed to fill up rapidly, the deepest water on the dike existing here.

The accretion or reef formed by the curtains came to within 3 or 4 feet of the surface as a ridge of 100 or more feet in width with the dike in the center and water of the ordinary depth on either side.

The effect was to cut out deep, narrow channels through the bar over which water flowed to the chute and to enlarge it somewhat. An examination showed this bar to be largely composed of heavy gravel, and but for this the result might have been more favorable.

This, however, may well be doubted. A study of the cross-sections made the past two seasons at Nebraska City reveals the fact that as a general thing on a rising stage chutes enlarge relatively faster than the main river, while the reverse is true of a falling stage. The fact that the chute was not only prevented from closing farther, but even enlarged, implied an efficient construction. In any case the attempt to close a larger channel in the unstable strata of the Missouri is a most doubtful undertaking, and it is thought it will be found expedient, especially if the course desired is longer than the present channel, to force it overland by cutting away the intervening area.

The cost of these two dikes complete was 47 cents per linear foot, the curtains being in double rank.

The most unsatisfactory portion of floating-dike work are the buoys. Oil barrels were first used, and afterwards boxes of about 4 cubic feet displacement; 130 experimental buoys were made of building paper, cylindrical in form, with board ends, and at a cost of about one-half that for boxes. The paper was passed through hot pitch as it was rolled on in three turns or thicknesses, the edges being closely tacked. They proved impervious to water and lasting. There are many practical difficulties in their construction, but the experiment demonstrated the feasibility of making a very cheap and efficient buoy from paper pulp. The rate of fill behind the dikes was by no means regular. On one occasion, from Saturday night to Monday morning, a fill of 6 feet was noted over a considerable area. From August 21–23, the fill over the upper half of the area behind the Wyoming dike was at the rate of 7¼ yards per minute. Much greater rates no doubt obtained elsewhere, but the difficulty of measuring it was very great.

The proper season for operations of this character is during the higher stages of the river, when the material transported is a maximum, the erosive forces at their height, and the stream itself less flexible in its course. As the work when commenced at Wyoming was essentially experimental and necessarily slow in progress, the river had fallen greatly before any efficiency was developed. The results finally obtained at low-water showed that the construction possessed such merit that it was deemed wise to develop it to the limit of our resources in order to settle, if possible, in some degree, one of the steps by which river courses might be directed and controlled.

It was not expected that the results obtained would be permanent unless secured by more substantial constructions, especially as the curtains used were too narrow to resist high-water. The impact of the current at Wyoming was directly against the

dike and this point continually moved up stream, threatening to cut it out at the head.

To secure the results and make them permanent it was the intention to develop a curved shore line from Neligh's to the crossing from Civil Bend by the aid of mattress work sustained by piling. By the time this plan was to be put in operation the money proved inadequate, and it was changed to closed dikes extending from the bluff to the proposed curve, 3 being of stone and of short length, and a fourth of mattress work and curtains sustained by piling nearly 1,000 feet long.

It was thought these constructions would preserve the directions desired during the first rises of the spring, or until additional funds were available, when their ends could be connected and this shore line finished in accordance with the first plan. This dike construction was not regarded as the best, or as a certain plan, but simply as the only one expedient at the time.

The stone for dikes deserve no special mention. They were quarried at their sites, and of short length, and the cheapest construction for the purpose.

In studying the question of piling it was found that, as driven in the ordinary way, the penetration in Missouri River sands was quite limited and the cost not warranted. A temporary hand-pump was rigged up, and experiments made with a jet. As the power of only 6 or 8 men was available on this pump, the manner of applying the jet most effectively was of great importance, and after much experimentation the method illustrated was thought to give the best results. It was found possible to sink piling of 1 foot diameter 8 to 12 feet, the average being about 10, in one to three minutes. With greater power and more efficient apparatus the depth reached would be anything desired.

The piling were put down at an inclination, in pairs like a letter A, and drift-bolted at the intersection, these bents being 12 to 15 feet apart. A stout log or waling was raised from bent to bent and well drift-bolted in the angle, thus making a structure that was very rigid. The general plan was to weave a very strong and wide mat over the end of this pile support and back 150 to 200 feet, and to complete the remaining portion of the dike in pile bents, 20 to 25 feet apart, between which a wire rope should be suspended for the purpose of sustaining curtains or a wire net.

The structure had progressed a few bents only, when peremptory orders to stop work without delay were received, as the funds were exhausted. The stone dikes below were only partly complete, perhaps fortunate under the circumstances. It is hardly necessary to say that the failure to finish these structures was greatly regretted, as all that had been gained at the head of Copeland's Bend seemed in fair way to be lost.

After the works were definitely closed, the river cut its way around the head of Wyoming Dike, and a good portion of the water flowed in this course during the winter. Only a limited portion of the lower end was carried away by this new attack, the main portion of the accretion remaining undisturbed. The unprotected pile bents stood nearly all winter, but were finally run down by ice fields. The lower dike continued to make accretions which extended nearly one-half its length above water, and some of the paper buoys were observable after the ice left the river. The effects of the April rise were watched for with great anxiety. The accretions thrown up at Wyoming maintained themselves, and so directed the river's course below that considerable erosion of the right bank took place below Squaw Creek. The channel ran outside the lower dike, and made a heavy inroad into the bar below, and most desirable changes took place in the chute. This action continued favorable until the 1st of May, and up to this time a small expenditure could have carried out the changes inaugurated so unexpectedly under the circumstances. Since then the lower end of the Wyoming Dike has gradually worn away, allowing the river to make such a bluff contact that the direction below is unfavorable. The river has to a certain extent swung across the lower dike, and a partial channel has developed over the stiff-weed portion. The river shows a tendency to abandon the favorable course it had taken below and swing back partly to its old course.

I believe, however, that these changes backward will be only partial, and that when the water goes down a substantial advantage will have been gained. Already the river has cut away the point of land at △ 355, and now runs nearly straight from a point below Squaw Creek across the bar below △ 355 to a point just above the Nebraska Island Slough, where considerable erosion has taken place.

The erosion around Eastport Bend has been less than usual, no serious damage has been done, and Eastport is sufficiently safe for this season.

The mattress work at Walnut Creek, although it stood the pressure of the entire river under direct flow for some time after the April rise, remains in good condition. The mattress work at Lambert's Orchard was in good shape after the April rise and up to the 1st of June, and at that time the shore line above and below it for a considerable distance had cut to a fair line, and it should have been extended according to the original intention. Meantime the bar opposite, which previously had thrown the impact of the river into the bank near Waubunsie Creek Slough, had cut away, allowing direct flow against the work with boils and a strong current similar to what was

encountered at Eastport Point last season. The main body of the work stood this direct action well. A powerful eddy at the immediate foot cut out the mattress work from below, and under the action of the current it gradually whipped out from below or unraveled up stream. An eddy also started in above the work and a similar whipping out took place from this end, accompanied by an occasional rolling up of the mattress in considerable masses. At the present writing this work is quite destroyed, not by slipping or tearing but solely by the action of the two ends.

The mattress work placed on Eastport Point last season in 60 feet of water is in good shape with this exception. The change of the river has produced 40 or more feet of deposits; the strain has been greater than the mats were able to stand, although specially made to resist strains of this class, and in many places they have parted at the crest of the bank, leaving a slight gap which was disclosed by the heavy storms of May.

Where the surface portion was woven on the system described in Assistant Yonge's report to you for 1879 there seems to be enough elasticity or stretch to allow for moderate settlement, and no rupture has occurred.

The storms in May were very severe and cut benches of 6 feet depth in gumbo bank and back 20 or more feet so that a very efficient upper bank protection is required.

The sand fence has thrown up a remarkable bank, far above high-water and quite continuous. A portion of the outer end was cut away by the water that gathered on the bar and concentrated at that point in its escape. The grasshopper frames that were placed across the slough were quite successful in accumulating drift and thus gradually closing that outlet. A small channel has cut through the fence at one point where the bank was low. The old sand fence on the island bar has thrown up dunes which are visible at a long distance.

The experience of this year is very encouraging. I know of no failure that could not have been turned into a most unqualified success had even a limited amount of money been available so late even as the 1st of June. As it is, the advantages gained are believed to be substantial if followed up.

The present system of appropriations for the Missouri River cannot be too strongly condemned. In a given piece of work designed to effect changes in direct conflict with the forces of the river, the cost cannot be foretold with certainty any more than the cost of a battle. If the money available is limited you are obliged to undertake that which, short of completion, will probably result in total rout. If an assistant could rely on the money being at hand when his judgment required its use, it is safe to say that a given improvement could be effected for one-half what it now costs, and in many cases for one-third, for too often the auspicious moment is past when the money is in hand.

Neither can the lines laid down in the project of to-day and the plans for their execution be always followed to-morrow, except in the most general way, for conditions change demanding a different treatment, and often so promptly that the assistant must be left solely to his judgment and unhampered by restrictions as to his methods or his resources. Such restrictions compel him to the defensive rather than the offensive, to fortify rather than take the field.

Limited appropriations compel the abandonment of that part of the project above Wyoming, although such a course will increase the ultimate expense. It is impossible to work safe between Jones's Point and Wyoming, and secure early results, without considerable money. It is possible to commence on the bar opposite Neligh's and secure results slower and with more expensive works, but still substantial results with each appropriation however small, and it may be that the river above will not become intractable until the course from Wyoming to Nebraska City is worked out. Then this upper reach may be taken in hand, an ultimate necessity in any case.

Conclusions.—The conclusions in regard to mattress work expressed in last report have been fully confirmed this season and applied in part.

It is at present believed that mattress work to resist flow nearly tangential must be of about 120 feet width from top of bank, and for direct flow twice the depth of permanent strata, and continuous in all cases. It should be much stronger than any hitherto made, and not liable to ravel or whip out as is the woven mattress. Severe wave action must be provided for.

In the construction of a strong, thin, and flexible continuous mat, a substantial advance has been made by Assistant Nier. A further advance would be to weave a thin mat on a strong wire net. This would give the strength desired with a minimum of brush, and it would not be liable to whip out; it would also enable the rock to be secured to the mat before sinking, which I believe to be an absolute necessity. This need not increase the cost, as on the certainty of the rock being properly distributed and absolutely fixed in place, not more than two or three pounds to the square foot would be required.

The upper bank protection is still the difficult part of the problem. Here to successfully resist wave action a mattress of at least a foot thickness will be required, and probably none better than the woven mat, woven on a continuation of the net of

the under-water work, will be found. By using a packing of hay the thickness may be reduced, as nothing better than bottom hay has been found for resisting the swash of the waves through a mat. This bank protection should be laid down late in the fall or early in the spring, and covered in with earth in order that the willows of which it is composed may grow and afford a permanent upper protection when this portion of the mattress has decayed.

The bank on which the protection is laid should be graded not less than 3 to 1, and probably this can be done cheapest with a jet. The apparatus necessary can be readily adapted to sinking piles to any depth and inclination, and to snagging, and thus serve a variety of purposes.

The chief difficulties of mattress work on the Missouri lie in the mobile nature of the material. If the mat is weighted too heavy it settles or sinks into this material, and may be carried bodily out by the viscous flow of bank. If too light, it is liable to be lifted and wrecked by the current. In localities the bank has been observed to melt, as it were, and run out through the interstices of the mat, leaving hollow spaces behind. Again, waves have even run through well-made mats, cutting out benches on vertical faces, not observable except on close inspection.

To provide for some of these difficulties, the mat can be fastened along its upper edge. Then the sand of the lower strata may ooze out from external scour without causing an undue strain; but when this action proceeds so far as to allow the upper strata of gumbo to break away in large masses of many tons weight, it is not easy to make a construction of sufficient strength. This difficulty may be obviated, in part, by very flat grading, or, better still, by a wide berme at low-water, if it be feasible.

All these troubles are greatly multiplied in purely local works subject to direct flow, where deep scour is occasioned in part by the revetment, causing a slipping of the material under the mat, and strains not easy to provide for. Most of the work put in contemplates flow nearly tangential, and to secure this involves a complete rectification from some point, generally of bluff contact, at which the river is likely to run for many years.

The same mobile material which makes revetment difficult makes rectification comparatively easy, provided the constructions are placed on the sites of causes, or at those places where directions may be determined, rather than on the sites of effects. The failure of nearly everything in the nature of a spur or wing-dam, which has not been raised entirely above overflow, has been quite uniform, for the reason that they are generally opposed to direct flow, and seek to divert the course of a stream by damming or obstructing it rather than by directing it. After a high-water it is frequently found that the bed of the stream is raised to the level of the dike or spur, the channel taking its old course, which may be over or through the construction. Over Boehmer's Dike, which was but 700 feet long, for two seasons the water ran with a fall of 6 to 8 inches, not over 3 feet depth existing outside its limits at low-water stage. Yet with this head, and ample opportunity to run outside or take the chute, the river persisted in this course until changes above threw its direction outside the dike. Then, in the space of two weeks, the dike and nearly 50 feet of water was entirely filled in beneath a sand-bar, and from causes which it was powerless to influence.

By working from crossings or convex fronts in easy directions, these difficulties may be largely avoided. A dike construction on a concave face alters no cause, and its utility is problematical. Its success, if any, is due to main strength, and lasts unti that strength is exhausted, or until nature herself ameliorates conditions above.

For general use it is thought a curtain of wire alone, or a wire net with meshes oı 8 to 15 inches, depending on the stage of water, will be found best and cheapest. This net should be made and placed continuously, which is not difficult. Its lower edge may be anchored with rock wired on, and its upper edge sustained by a wire rope suspended from piling where the water is not too deep, or otherwise by buoys.

The advantage of piling, which need not be more expensive than buoys, is that the net cannot creep down, and it may be sustained near the level of high-water, so that it can be placed during a moderate stage, and in anticipation of a rise. The April rise probably moves more material locally and initiates greater changes than all subsequent high-water. It is, however, so sudden and violent and short in duration that to properly utilize it requires works previously placed.

There are many situations also where mattress work sustained by piling could be placed advantageously at once, as along a half-developed channel, where it would be clearly inexpedient otherwise. The jet, presenting as it does a cheap and in fact the only way in which piling may be sunk in Missouri sands to adequate depths and to any angle, becomes at once an essential apparatus.

A hydraulic engine, capable of throwing a very large volume of water under considerable pressure for the purpose of assisting and directing erosion, trimming up the irregularities of shore lines to be reveted, cutting out bars and channels, snagging, quarry stripping, &c., is thought to be an engine of immense possibilities, and to be considered as part of the plant in any systematic scheme of improvement.

There is one important thing to be arrived at, viz, rapidity of execution on short

notice, and with few men. Cheapness may follow, but it is too often deceptive when not coupled with rapidity. To secure these objects requires as much of the material as possible to be kept in stock and in readiness. This is possible in every detail of wire-net or curtain dikes, which may be placed at the rate of 1,000 feet per day if desired, and at a cost of 25 to 50 cents per foot. With mattress work it is possible to keep all the material on hand except the brush, of which the plan requires a minimum, and it is believed it may be placed at the rate of 500 feet per day, and at a cost of $1 to $1.50 per linear foot for widths of 100 to 125 feet.

I desire to express my appreciation of the services of Mr. A. S. Potter, who, while exercising a certain general supervision, was in immediate charge of mattress work and general experiments.

To Mr. F. M. Harris, who had immediate charge of the development of curtain and wire-net construction, much credit is due, as in constructions so novel he had continually to work against the prejudices of practical foremen and laborers.

I take pleasure in commending the services of F. W. Tuttle and L. E. Cooley on surveys, and of Mr. C. F. Potter on miscellaneous duties.

I am, major, very respectfully, your obedient servant,

L. E. COOLEY.

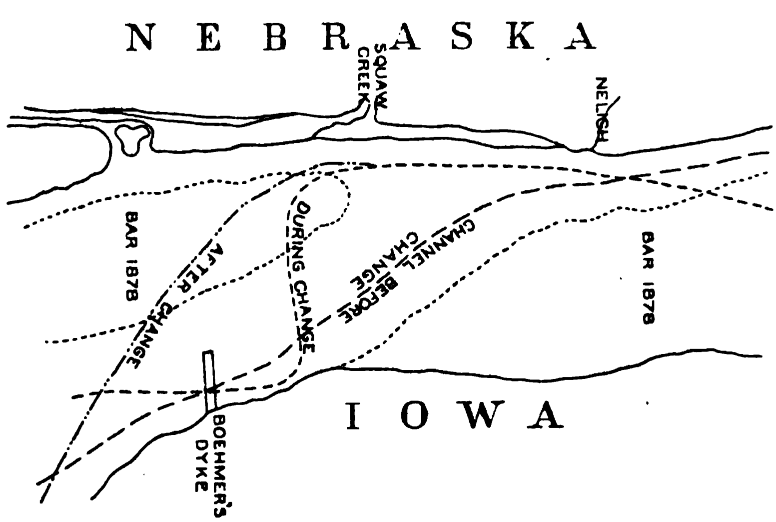
Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

LIST OF ILLUSTRATIONS.

NOTES OF ILLUSTRATIONS.

The main report is sufficiently descriptive of sketch No. 1.

In sketch No. 2 the channel shifted position at Boehmer's Dike in the high-water of 1877, occupying at the time of the construction of the dike very nearly the position shown for 1878. The bar above had also retreated, and the large bar bounding Walnut Creek chute reached the 1878 limit before the dike was completed.



In the high-water of 1879, the channel abandoned the dike, taking the position shown in sketch No. 3. The cause of this change and its reason for not going farther is explained in the report.


WEEPING WATER BOTTOMS
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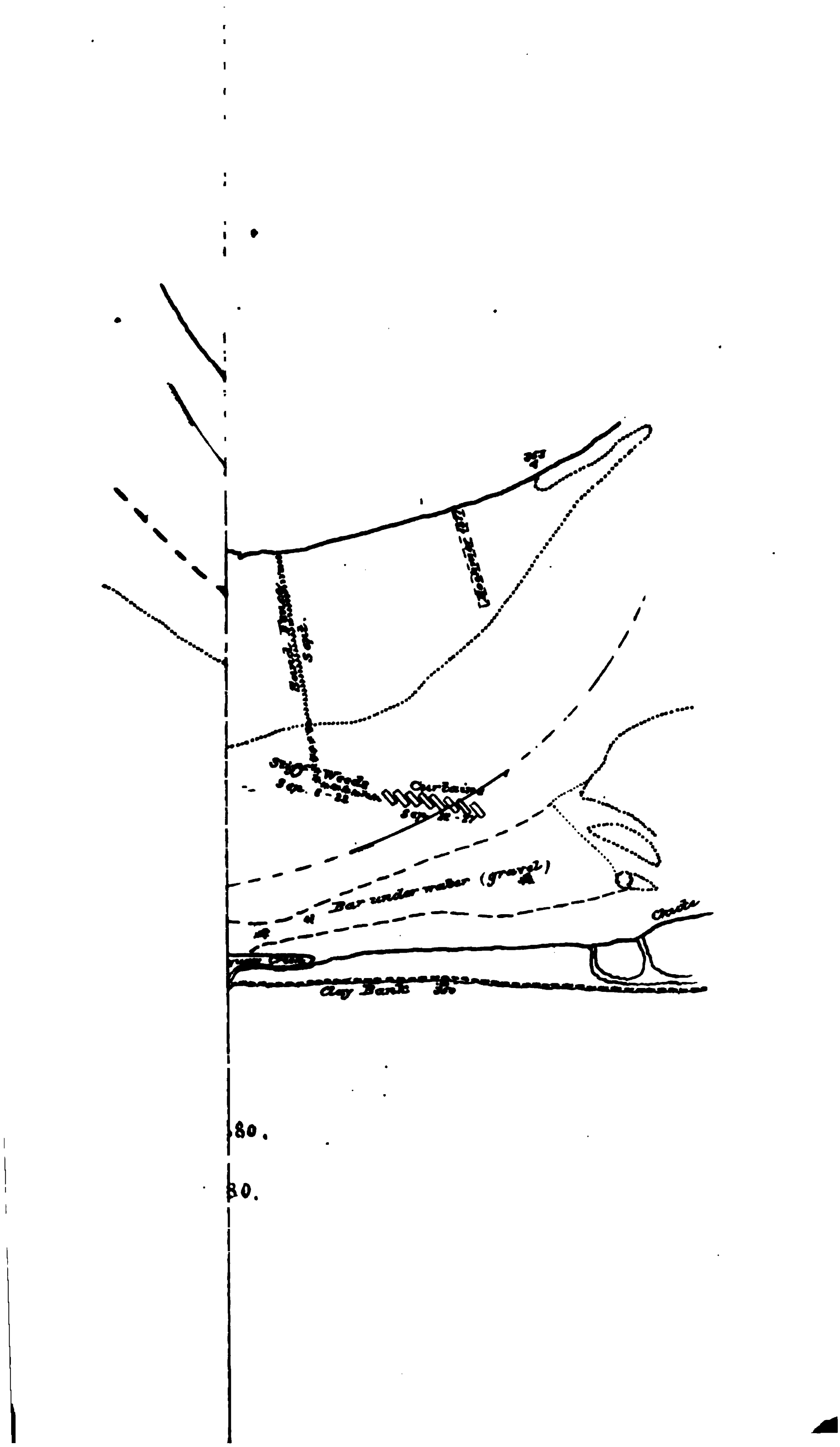
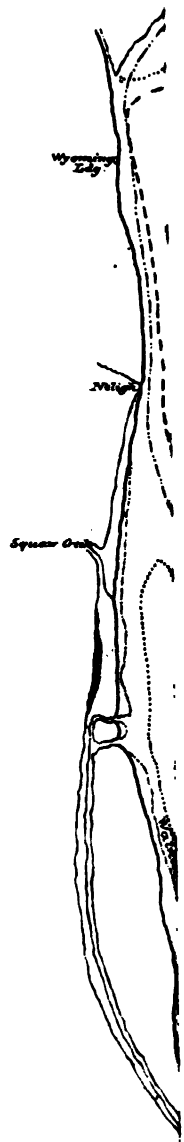
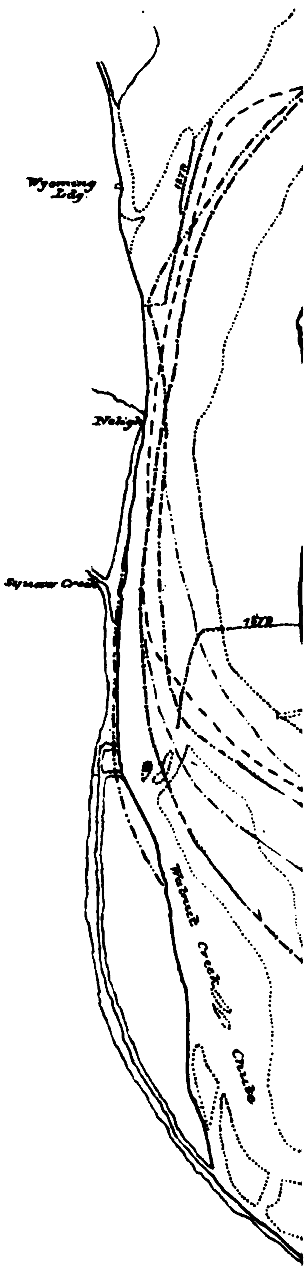

Curtains
Bar under water (gravel)
Clay Bank
80.
80.


Wyoming Ldg
Squaw Cr


Wyoming Ldg.
1878
1878
Walnut Creek
Chute

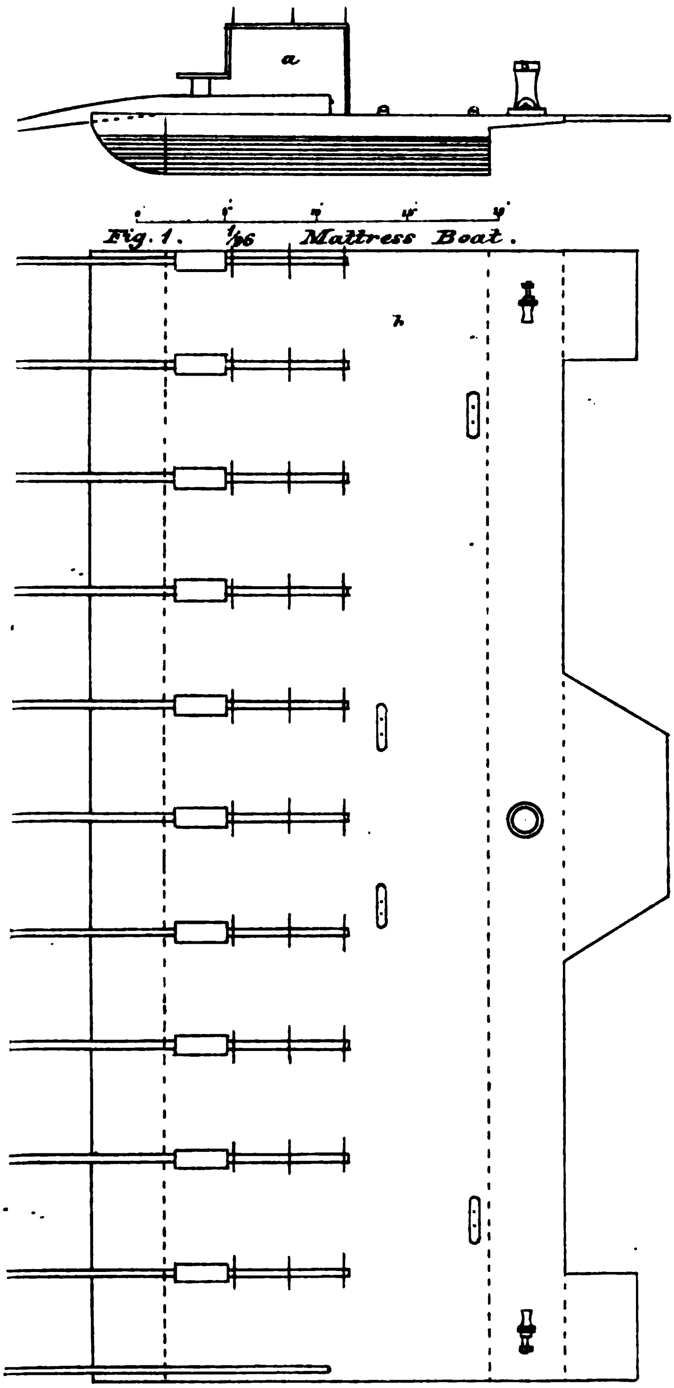
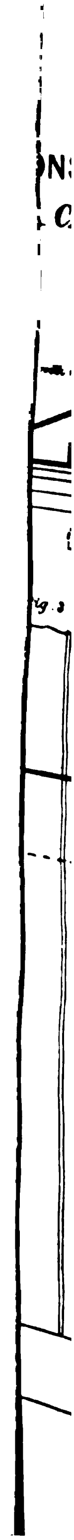


Fig. 1. 1/96 Mattress Boat.



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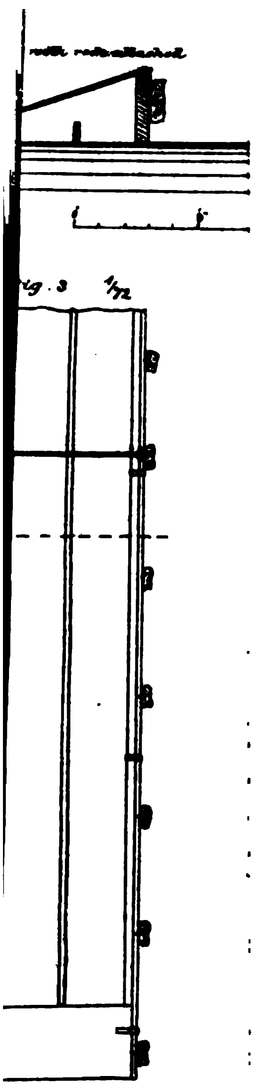


In making the change the channel at first took the course illustrated in the adjoining sketch, coming down nearly to Squaw Creek and then crossing squarely over to a point about 1,200 feet above the dike, where considerable bank erosion took place. This double fold or reverse moved bodily down stream, and finally, in the course of two or three weeks, it straightened out in the course shown for 1879, abandoning the dike and the 47 feet of water behind it, which was filled up to the top of the water in the course of a fortnight. This doubling or reversing of the channel was noticed also in the changes which occurred in 1880, causing extensive erosion near △ 355. This channel has also partly straightened out, but in a contrary direction, as the forces above have not persisted until the change initiated was carried through to its legitimate conclusion.

Similar phenomena have been observed at other times, and it is thought to be the method of working in extensive channel changes.

Plate I. Mattress constructions.—Fig. 1, A and B, elevation and plan of boat. This construction possesses no special merit. It was necessary to give considerable length to the needles in order to provide deck room. The boat once upset or turned on edge, doing no particular damage, however. Afterward a barge was lashed to the rear gunwale.

Figs. 2 and 3 illustrate the manner of starting the mat (*c*), the way in which it hung from the boat (*a*), the system of lines (*b*), and the position when laid (Fig. 3).

Fig. 4, *a* and *b*, illustrate the tension device, which was secured to the rear gunwale. This was made of 2½″ gas-pipe with cast spools of capstan form, about which the tension lines passed. It was found that no other form of spool would clear the line freely.

Plate II. Curtain construction.—Fig. 1, *a* and *b*, shows the ways on which the curtains were constructed, the manner of producing tension in the wires, and a curtain partly rolled up. Fig. 2, *a* and *b*, shows the wheel and awl used in making the twist a fastening; *c* shows the manner in which the wires are fastened together, which has been often misconceived, and *d* shows a section of curtain as thus fastened by parallel wires. The constructive merit of the curtain consists largely in this twist or fastening, which is efficient and reliable.

Fig. 3, *a* and *b*, illustrates the position of the tumbling beam and the curtain anchors as suspended thereto; and Fig 4, *a* and *b*, illustrates the system of lines and successive positions of the barges, and a curtain before and after launching. Owing to the square sides of the barges the drag on the moorings was very severe. A special barge with curved sides would be comparatively easy and safe on its moorings.

Fig. 5 illustrates the successive positions of the curtains in an assumed dike. Fig. 6, *a* and *b*, represents the modified type of Chinese anchors, devised after much experiment with other kinds.

Fig. 7 illustrates the form of wire net actually made and placed, the action of which has been previously described. Fig. 8 illustrates the manner of making an hexagonal mesh, or one approximating thereto. It consists simply of a board or template, through which the wires pass. The size of the meshes may be regulated by the distance apart of the holes in the template and by the distance the template is moved for each series. If the mesh required is large, two templates, carrying alternate wires and moving alternately in opposite directions, and again in same directions—a half mesh for each series—may be used. Since the general form of Fig. 8 was devised, it has been put in use by Mr. Harris, at Omaha, under assistant Davis, substantially as described.

It is a fact not previously noted that a curtain dike does not cut out at the immediate end as it progresses. The flow of water being so free immediately back of the end, for the time being, the curtains are to a certain extent protected until they commence to load up.

Plate III. Jet Piling.—Fig. 1 illustrates the arrangement of derrick employed for experimental work, and Fig. 2 the manner of preparing the butt end or foot of the pile, in order to produce a three-fourths-inch jet or flow in the direction of the axis. Fig. 3 shows the general arrangement of piling for supporting a mat. Not enough of this work was done to furnish a basis for a fair estimate of cost, but it is believed that for mattress work it would not greatly exceed that of properly grading heavy banks, and for curtain work that of wooden or box buoys.

L. E. COOLEY.

Q 12.

IMPROVEMENT OF MISSOURI RIVER AT PLATTSMOUTH, NEBRASKA.

A general plan for improving the Missouri River in this vicinity was submitted to you under date of January 30, 1880, and published as Senate Ex. Doc No. 77, Forty-sixth Congress, second session.

With the appropriation now available work will be begun in the vicinity of Plattsmouth and pushed as far as the funds available will allow.

This work is in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	490,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	200,000 00

Q 13.

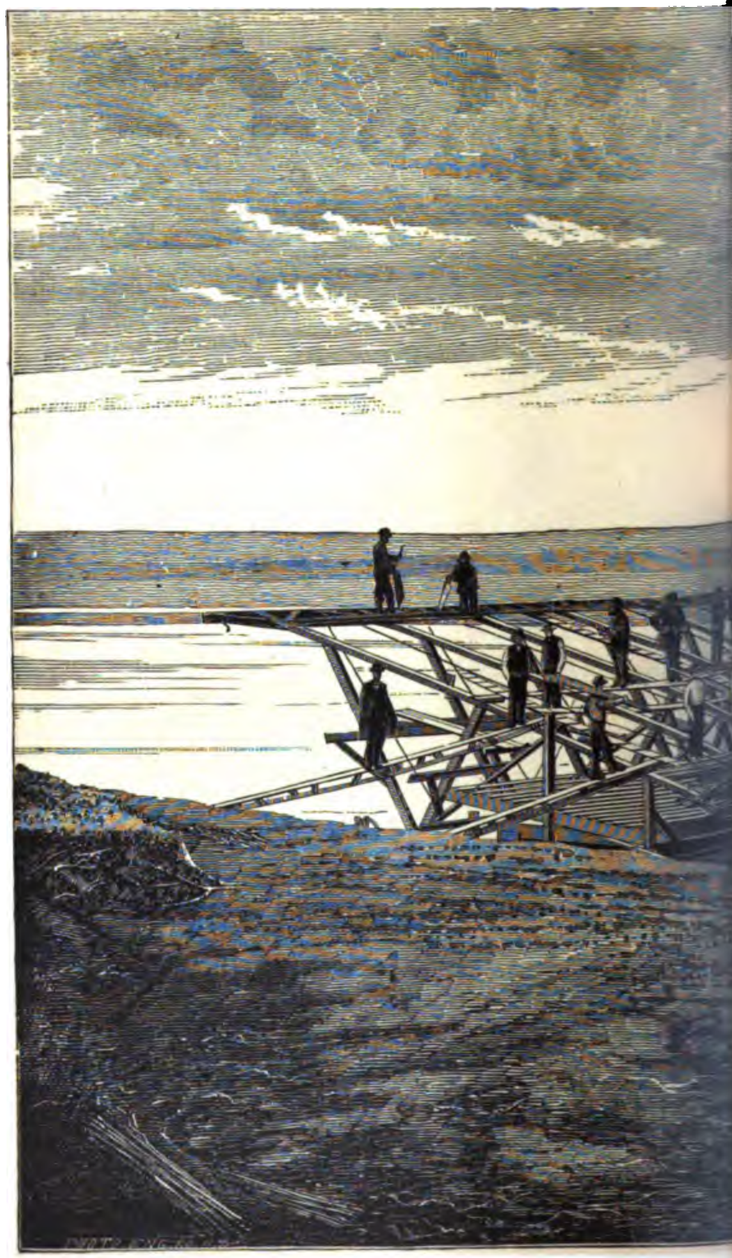
IMPROVEMENT OF MISSOURI RIVER AT COUNCIL BLUFFS, IOWA, AND OMAHA, NEBRASKA.

At the date of my last annual report work was in active progress at this place, extending the bank revetments and works of channel rectification. During the season the work made satisfactory progress. A total of 5,550 feet of bank revetment was constructed, of which 700 feet was a woven mattress, similar to that used at Vermillion, Dak. This was an extension of the lower end of the Omaha revetment. The Iowa revetment of 1878 was extended down stream 2,650 feet. In this work a novel form of continuous mattress was used. It was built from a floating ways, which were drawn out from under the mattress as fast as lengths of 40 to 60 feet were completed. The willow brush, of which it was composed, was not woven, but was sewed on to continuous lengths of wire, which furnished the longitudinal strength required. The thickness was about 8 inches and the width 95 feet from the water's edge. The upper bank protection was a woven mattress.

The upper portion (1,200 feet) of the Iowa revetment of 1878 having been carried away by a change in the channel in the bend above, it was decided to take advantage of this accident and adopt a new shore line more favorable to the lower work. To prevent too great a recession of the shore line, a woven revetment 2,200 feet long was constructed on the surface of the ground above the old work, it being expected that when this mattress was reached by the river it would fall in and protect the bank. This object was in a measure realized, though the difficulties and cost were greater than anticipated.

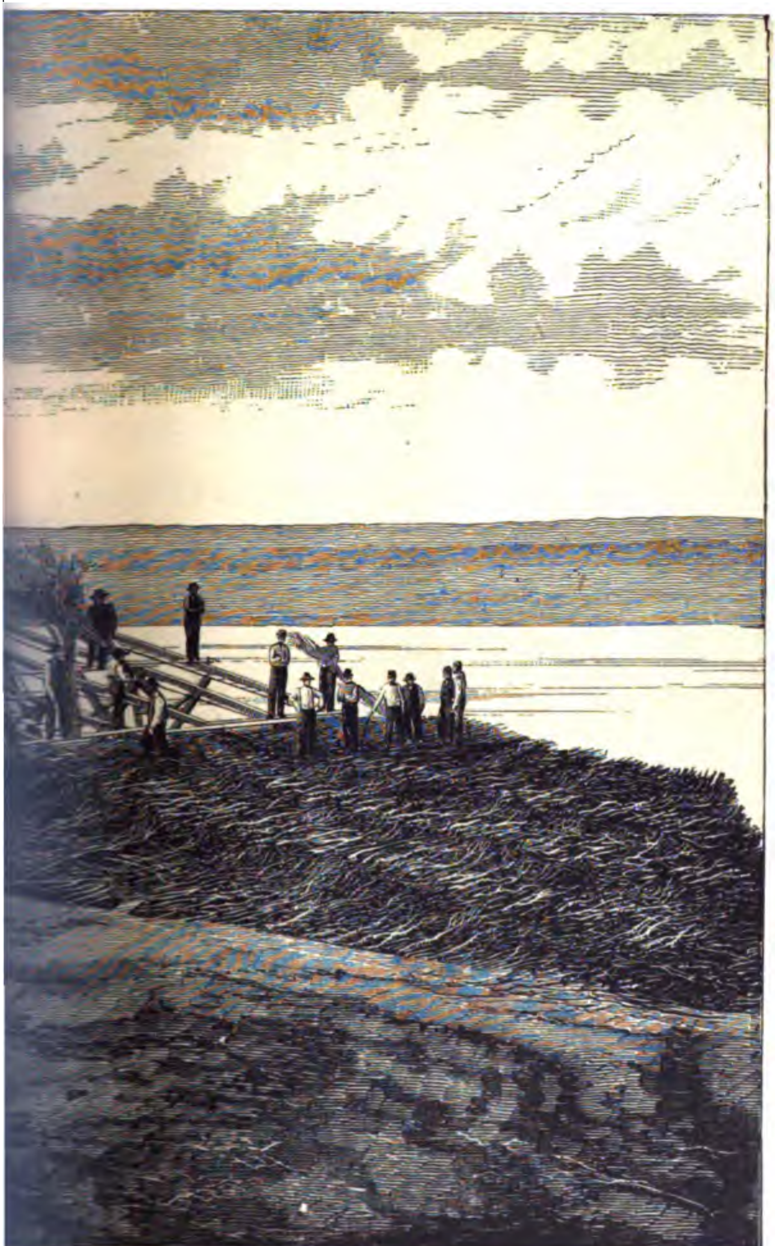
In the way of channel rectification there was not much accomplished. The weed dike described in my last report was perfectly successful, as was also a 600-foot dike of the same character put in for temporary purposes near the head of the old Iowa revetment. In the spring of 1880 it was deemed necessary to extend the work into the bend below Florence, where the channel changes had occurred that caused the damage to the Iowa revetment. A floating dike was built here 800 feet in length composed of a continuous wire curtain, or screen, having large open meshes.

The width of the curtain was 30 feet; one edge was anchored and the other buoyed. This screen was expected to catch the small floating drift and thus accumulate sufficient surface to make it an efficient current arrester. The meshes were diamond-shaped, with diameters of 16 inches and 24 inches, the latter vertical. A hexagonal mesh of 10 inches



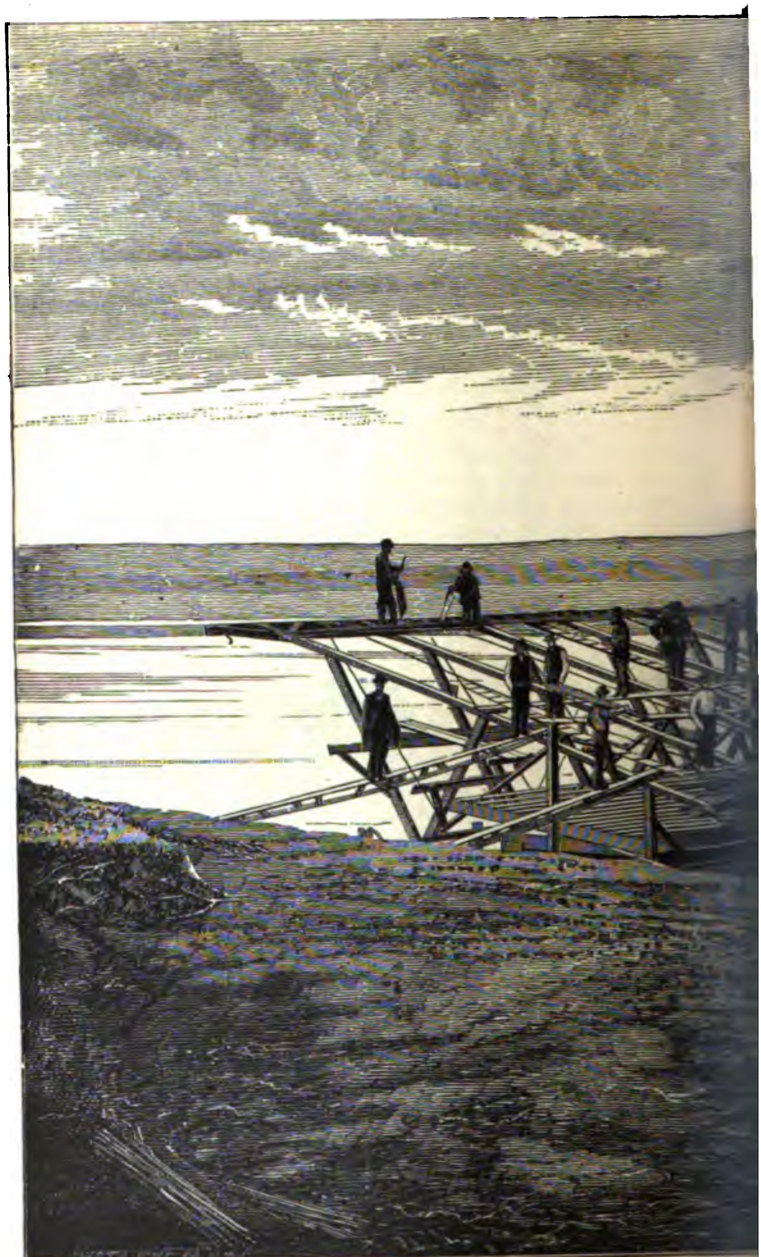
IMPROVEMENT OF THE MISSOURI

LOWER IOWA REVETMENT. CONTINUOU



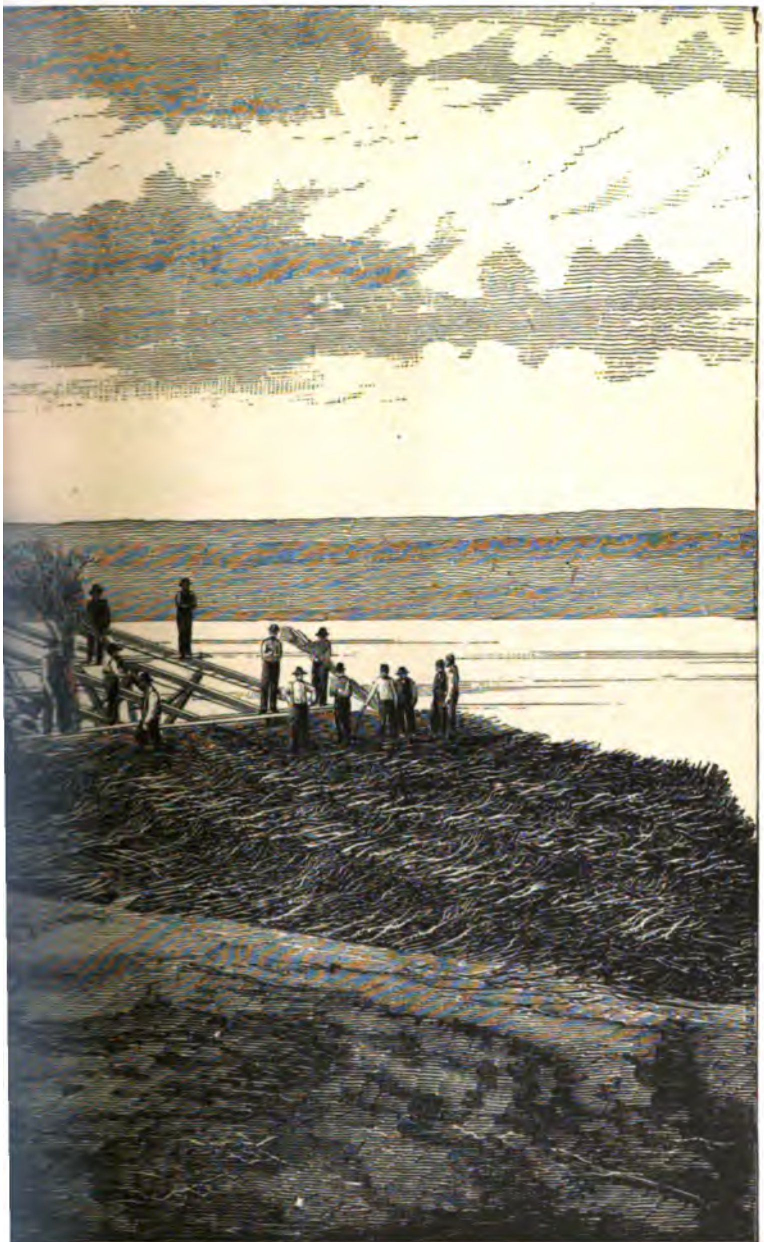
—OMAHA AND COUNCIL BLUFFS.

D MATTRESS—LOOKING DOWN STREAM.



IMPROVEMENT OF THE MISSOUR

LOWER IOWA REVETMENT. CONTINUOU



-OMAHA AND COUNCIL BLUFFS.

MATTRESS—LOOKING DOWN STREAM.

diameter was also used. The experiment was perfectly successful as far as carried out, but funds were lacking to follow it up. The mesh used proved much too small and arrested so much material as to drag the curtain under water before its full effect had been produced.

All the work remains in a very satisfactory shape and the present appropriation will be expended in further prosecution of the general plan. For information concerning the details of the work, I beg to refer to the accompanying very interesting report of Assistant C. B. Davis, who had charge of the work.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$39,735 82	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$59,735 82
July 1, 1880, amount expended during fiscal year		38,391 31
July 1, 1880, amount available		21,344 51
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		60,000 00

REPORT OF MR. CHESTER B. DAVIS, ASSISTANT ENGINEER.

COUNCIL BLUFFS, IOWA, *July* 19, 1880.

MAJOR: I have the honor to submit the following report concerning the work of improving the Missouri River in the vicinity of Omaha, Nebr., and Council Bluffs, Iowa, for the year ending June 30, 1880. The work is described under the following heads:

I. Floating dike near Union Pacific Railway Shop.
II. Floating dike at the head of the Iowa revetment of 1878.
III. Hydraulic bank grading.
IV. Extension of the Omaha, Nebr., revetment.
V. Extension of the Iowa revetment downstream.
VI. Surface mattress.
VII. Floating curtain dike at Tarbox Point, 1880.

Previous to September 1, 1879, all work executed was in accordance with the plan first proposed and approved, with this modification. Instead of attempting to cut the point of the Iowa shore opposite the smelting works back to an easy curve from the lower end of the Iowa revetment of 1878 to the Union Pacific Railway Bridge, an attempt was made to cause the river to take a curve at this place, having a radius of 4,500 feet.

A change in the plan for the whole vicinity except along the Omaha City front was necessitated by the serious changes in the shape and condition of the river which occured during the summer high-water.

The revetment of the Iowa shore during 1878 was stopped at a point about one mile above the mouth of Iowa Lake, and for some reason no attempt was made to secure the head of the work from being flanked by the river, probably because the main channel of the river was to the west of Willow Island and the foot of the crossing below the head of the revetment.

During the high-water and its subsidence, the discharge through this chute was thrown almost directly against the Iowa shore at the above place. By September 1, about 1,200 feet of the revetment had been carried away, and a pocket over a mile long and having a maximum width of about 800 feet was cut into the shore. Leaving this pocket the channel crossed to the Nebraska shore, eroding it severely until it crossed back to the Iowa side below the revetment in front of which a large sand bar had formed. Although its effects upon the work of 1878 in its vicinity were very severe, the change furnished the foundation of a much better plan of improvement, the points wherein it differs from the old plan being briefly stated as follows: 1st. (*a*) Instead of continuing the Iowa revetment of 1878 as far north as the Chicago and Northwestern Railroad dikes, it contemplates continuing the erosion in the above-

mentioned pocket, until the shore reaches the line proposed, and revetting along this line. (*b*) Continuing the bank in a direction tangent to the lower end of the pocket through as long a straight reach as can be maintained there, allowing the channel to follow an easy curve around to a point in the vicinity of the smelting works. (*c*) Extending the Iowa revetment a sufficient distance down stream to protect the shore from cutting which would occur in making the changes above-mentioned (*b*).

2d. Executing such work as would hold the river in the pocket near Florence Lake and make a crossing to the Iowa shore immediately upon leaving the pocket, thus holding it away from the chute back of Willow Island, and bringing it by an easy curve into the pocket below the Chicago and Northwestern Railroad dikes.

FLOATING DIKE NEAR UNION PACIFIC RAILWAY SHOPS.

The extension of this dike was the first work of the year. It was complete July 10. The eddy which formed at its lower end being quite severe, a short spur was built out from the shore, through its center, which had the effect of breaking it up and facilitating the filling-in process back of the main dike. As the work was done mainly during the June rise, much of it in a depth of water of 45 to 50 feet, and in a velocity of over 8 miles per hour, it was difficult and expensive. The results, however, were very satisfactory. I noted a filling in of about 25 feet near the lower end in twelve days. By September 1, the shore had been built out 150 feet beyond the head of the dike, and even with its lower end, it being remembered that the dike was curved to a radius of 4,500 feet. A description of its construction was given in my report to July 1, 1879, and need not be repeated here. The imperfect action of the weed was clearly shown in this work by the deposit being anything but uniform in its depth. It being impossible to space the weeds exactly right with reference to the velocity of the current, the spaces which were larger than proper were forced wider, and until it was found that the whole deposit was cut up by channels varying in depth.

Another fault is found in their failing to stop the current at the bottom of the river. Both of these defects retard the deposits greatly.

The serious changes occuring during July, 1879, at the head of the Iowa revetment of 1878, and causing an entire change of the plan of improvement of the Iowa side, and above this dike so that the revetment has been left uncared for. A portion of the shore formed by it has been cut away.

FLOATING DIKE AT THE HEAD OF THE IOWA REVETMENT OF 1878.

As soon as the new plan of improvement was approved the cutting at the lower end of the pocket above the Iowa revetment having stopped, a 600-foot dike was built out from this point during October, 1879, with a view of protecting and building up the bar along the Iowa shore and of forcing the water against the Nebraska shore opposite to produce a heavier and more rapid erosion. Its effect was quite marked in each case. A filling of 5 to 6 feet occurred very rapidly, and extended out to near the end of the dike, while along the Nebraska shore the cutting increased until sufficient room was obtained to allow the river to curve without producing much pressure on the banks where it slopped except during a favorable wind.

No attempt was made to build the dike after a new or improved method. Its probable length of life was small, and there were "weeds" and other materials on hand sufficient for the work, which had been left over from other and similar work. The efficiency of the dike was considerably impaired by unknown parties stealing the buoys. Those which did not go in this manner were either carried out by the ice or cut off and saved. The cost per foot was as follows:

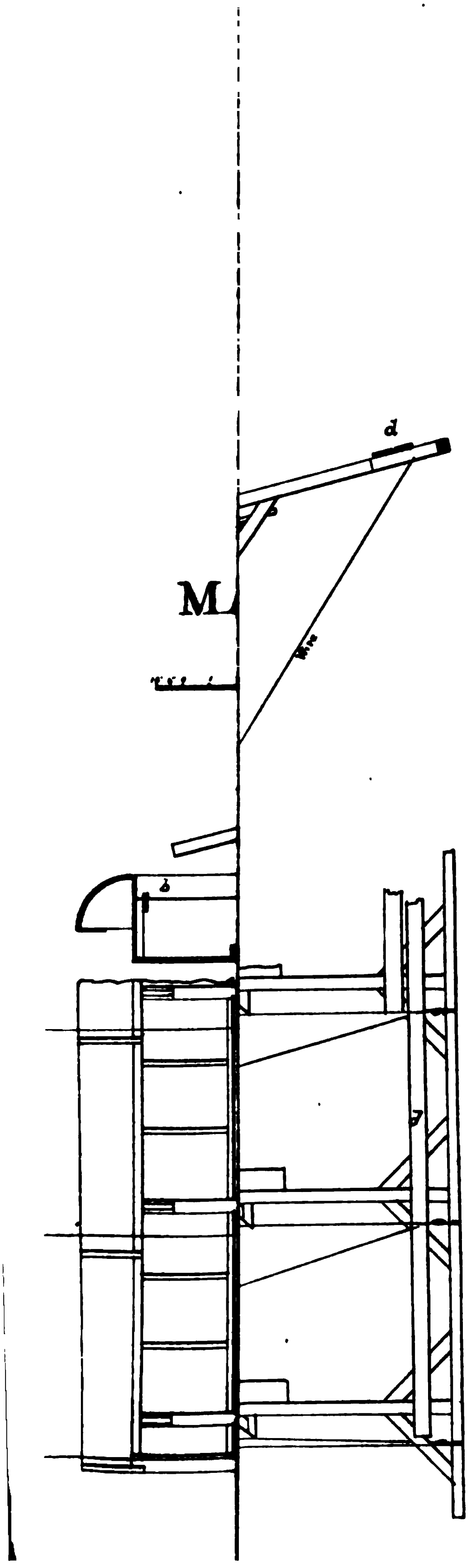
Rock	$0 15+
Weeds	81+
Buoys	12+
Wire	06+
Labor and superintendence	77
Total cost per foot	1 91+

Total cost, $1,150.

The dike was built in a 4-mile to 4½-mile current, and at an angle of from 15° to 25° with it. It was intended that this dike should be rebuilt and extended to 1,500 feet during the spring just passed, but a sufficient amount of funds not being available, the project was abandoned until a later date.

EXTENSION OF THE OMAHA REVETMENT.

The revetment of the Omaha city front during 1878 was stopped at a place 1,700 feet north of the Union Pacific Railway bridge. The plan of improvement for that vicin-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ity contemplates its extension along a line passing just outside of the second west pier, and as far below the bridge as may be required. A considerable amount of cutting is needed in order to get the shore back to this line. A distance of 705 feet was all that could be gotten in condition for the work during the year, and a revetment consisting of a continuous woven willow mattress was placed there during October, 1879.

A comparison of different surveys in the vicinity shows that the head of the crossing is moving down stream from 500 to 700 feet per year, so that in 1882 it would naturally arrive at the desired place, at least 500 feet below the bridge. In order that boats may pass the bridge safely, the crossing must be wholly below it, and the angle between the bridge line and the axis of the stream as near 90° as possible. At present this angle is about 60°. When the proposed improvement is completed, the angle will be increased to 75°, giving a clear, open water-way between the piers of 220 feet. The spans of the bridge are 250 feet each, and the greatest available water-way is 240½ feet for each.

The woven mattress used was very similar to the form used earlier in the year at Sioux City and Vermillion. The dimensions were:

Width on sloping bank	30 feet to 40 feet.
Width under water	60 feet.
Length	705 feet.
Thickness, net 8 inches	12 inches gross.
Total width, average	95 feet.
Total square feet	66,975

The connection with the old work was made by lapping the new mattress 60 feet on to it and sinking it securely by rock wired on to its upper end.

The cost of the work per foot of shore was $2.95, or about $1 per foot more than such work can be done for under favorable conditions. This difference is due to the small amount of the work done (700 feet), the difficulty in getting rock and brush, it having to be hauled part of the way and boated the rest, and to the difficulty experienced in keeping weavers after teaching them the work. A detailed statement of the cost of each part of the work would be of no practical value in estimating on similar work. The banks were graded partly by the use of picks and shovels and partly by a hydraulic method described farther along. (The slope adopted was 5 horizontal to 2 vertical). The shore portion of the mattress was well covered with earth after it was completed. The work is now in most excellent condition.

EXTENSION OF THE IOWA REVETMENT DOWNSTREAM.

During the summer and fall of 1879, owing to changes occurring farther upstream, the channel of the river was forced against this shore just below the Iowa revetment, and a large amount of the bank was cut away. As the work of cutting away the Nebraska shore would increase this tendency to cut, and as its continuance would be somewhat injurious to the general plan of improvement, it was decided to protect a portion of this bank by means of a light revetment. The effect, if allowed to cut, would be to relieve the cutting where it was greatly desired that it should occur, and also to increase the curvature of the bend below the pocket forming.

Work was commenced November 1, 1879, and the mattress, which was continuous, was formed by sewing together by wire layers of willow brush as described below. The bank was graded to a slope of 3 in 5, a portion being done by hand, but the most by the hydraulic method. Brush was obtained from the river bank below the bridge, the average length of haul being about 4½ miles, and a large portion of the rock came from the quarry distant about 7½ miles.

The mattress was built upon and launched from a mattress boat, a drawing of which and photographs giving two views accompany this report.

The mattress boat consisted essentially of a set of eight trussed "ways" supported by two scows. The ways proper upon which the mattress was made form the upper chords of the trusses, and are of 6 by 6 inches clear pine. The posts are also of 6 by 6 inches pine. The lower chords and ties are 2 by 10 inches pine.

At "*a*" is seen the flooring upon which the men worked while sewing and distributing the brush, and at "*d*" the walk for brush-passers, kept from from sliding down the ways by 1-inch pins.

The scows had a depth of hold of 3 feet, and were 60 feet long. The up stream one having the greater load to carry, was 15 feet 9 inches wide; the other was 12 feet wide. The former was provided with a rounded apron for its whole length to facilitate in launching the work. The whole weight of the trusses and their load was supported from the sides of the scows as follows: To the sides, directly under each truss, were bolted upright pieces of 4 by 6 inch, and a 2 by 6 inch strip was nailed to these, the whole length of each side 8 inches below the top. On these strips and nailed to upright pieces, were placed double 2 by 10 inch floor joist notched 2 inches near their ends to bring them flush with the deck.

The trusses at their points of support were provided with rough boxes setting on rounded bearing (supported by floor joist) in order that the structure might accommodate itself easily to the varying load during launching, which often changed the draught of the up stream 10 inches to 12 inches. This bearing in the up-stream scow was $\frac{1}{4}$ of the width (12 feet) from the outer edge of the scow, and was placed so in order to balance the overturning tendency of the mattress as it rested on the apron.

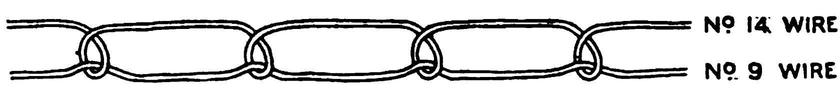
In the other scow this point is 1 foot back of the center, and balances the overturning moment due to the bridging between the scows.

The posts of this bridging were made up of two 2 by 10 inch joist separated 4 inches at their centers, and their ends were held in sockets at the sides of the scows by pins, thus completing the hinged system which allowed it to accommodate itself to any distribution of load.

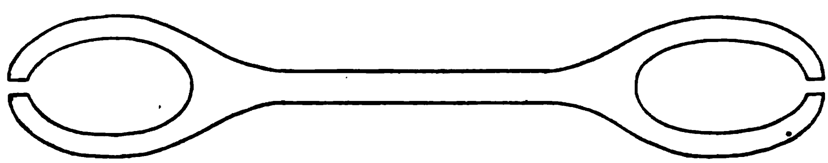
The separate trusses were securely braced laterally and their upper ends mortised into a 6 by 6 inch pine cap-piece. To this cap were lashed 9 iron sheaves ("hay-fork pulleys") on which were run the main wires of the mattress, the wire reels being in the back scow, as shown. The trusses were placed 8 feet apart, as long brush was abundant, but a much better result would have been obtained had the spacing been reduced to 5 feet. The slope of the top chord was 4 horizontal to 1 vertical.

With willow brush it was found to be difficult to make a thin mattress on this slope, as the brush slides down it and crowds closely together. Better results would have obtained from a slope of 1 vertical to 5 or 5¼ horizontal.

The construction of the mattress was as follows: At right angles to the "ways" and to the shore was placed a very thin layer of the longest brush. On this was laid a filling of from 4 to 6 inches of small willows, and above all was placed a third layer consisting of the longest willows, laid parallel with the first ones. This done, the whole mass was sewed along the main wires, located as described above, by No. 14 wires, the stitch being the one shown in the sketch.



The stitches were about 15 inches long and the two wires were securely fastened together every few feet. During the sewing the No. 14 wire was held on a double pointed shuttle of elm 30 inches long, as shown by sketch.



The mattress was made in sections of from 40 feet to 60 feet, and was launched to the water's edge by simply pulling the boat from beneath it down stream. The best day's work was 300 feet, but the maximum capacity would probably be 400 to 450 feet per day, could a sufficient supply of brush be furnished.

It was at first intended that the mattress proper and the shore or high-water protection should be continuous and made at the same time, but the delay in getting the boat rigged for work led me to weave the shore protection in a manner similar to the usual woven mattress, first placing a layer of old brush on the slope to stop the cutting due to the swash of the waves through it.

Total length of work	2,650 feet.
Total width of work, average	95 feet.
Thickness, average	8 inches.
Cost per foot of shore, complete	$1 90
Rock hauled and boated	8 miles.
Willow hauled over soft road	4½ miles.

The work stood the ice and the spring and summer rises of 1880 very well, indeed. The only damage done was to the high-water protection by drift, as it was in a very much exposed location.

EXTENSION OF THE UPPER IOWA REVETMENT.

As the shore above the point at the head of the Iowa revetment of 1878 had not at any point reached the line proposed and was very irregular, and as it was necessary,

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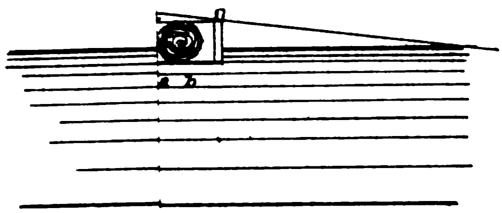
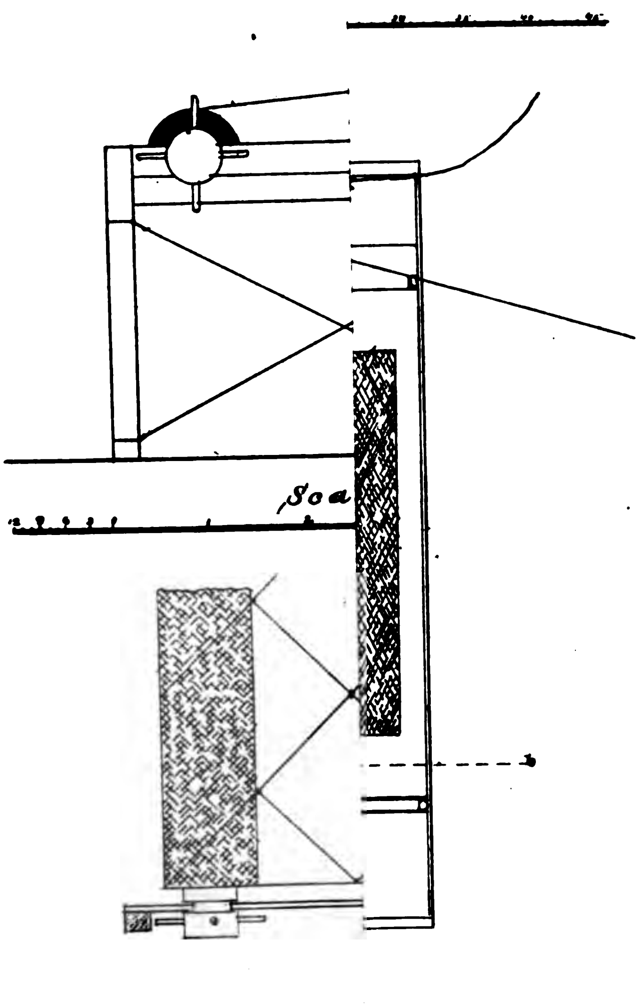




in order to hold this point, to place some sort of protection above it, it was decided to try the experiment of weaving a mattress on the surface along the proposed line from the point to a place up stream, beyond which it would be impossible for the river to cut behind the work and cause its destruction.

It was intended that when the river had eroded the bank back to the desired place the mattress being undermined would drop over the bank, and, settling against it, would stop the cutting when the limit of scour was reached. A careful study of the probable curve the river would assume if the point was held, or, in other words, the probable length of the proposed line which would be reached by the river, caused me to decide upon 2,000 feet as the necessary length of the revetment. In addition to this the upper end was curved inland for 200 feet to act as a "root." The width adopted was 120 feet, which is sufficient to provide for a scour of from 70 to 75 feet from the top of the bank. Work was commenced November 1, 1879, and completed during the same month.

In construction the mattress differed little from the ordinary woven mattress, and its cost was $1.90 per running foot, or 1.6 cents per square foot, completed, a portion of the rock being wired on. The willow for the work was hauled 7 miles by wagon and the rock about 3½ to 4 miles over very poor roads. The amount of work woven per day averaged about 100 running feet. The greatest amount woven in one day was 141 feet, or 16,920 square feet. The force employed averaged from 25 to 30 men. A day's work for one weaver, with a helper, averaged about 1,000 square feet.

The work was left uncovered during the winter and as the willows were cut very late in the fall they did not dry out to any considerable extent. During the spring of 1880 the revetment was severely tried and a considerable expenditure made to keep it in repair.

The spring rise was an unusually sudden one, changing from very low-water to a depth of 3 feet over the center of the mattress in about thirty-six hours. Its first effect was to cut away with great rapidity the point of land 200 feet to 300 feet wide outside of the work, and to cut considerably beneath it at the soft "slough" at its center.

A heavy north wind prevailing all the time the water was rising, and for several days after forced the drift with great violence against the edge, tearing it badly before the bank could cut away and allow it to drop beneath the water a sufficient distance to be protected by it. It struck with great violence at the point and 300 feet were carried away from the lower end before the work of repairing could be commenced. A bad break also occurred at the center where it crossed the soft slough and threatened to cut it into two pieces. As soon as the water got below the edge of the bank the torn places in the mattress were sewed strongly with wire and a new edge formed in that manner.

The water fell very rapidly, and the mattress hanging over the bank and fitting very closely to it began to be torn and pulled apart by the large masses of earth as they became detached and fell into the river. This necessitated sewing the whole mattress from the water's edge back and the adoption of several other devices for preventing these breaks, all of them more or less successful. As the bank became dryer and the caving less, the breaks all occurred immediately beneath the water's edge. These were very successfully stopped and prevented from increasing in size by sinking over the breaks a piece of woven-wire curtain, such as was used in the dike work, after securely wiring rock to it.

In this manner I succeeded in repairing all of the breaks and in placing the work into such condition that it stopped all erosion. When this result was reached the curvature of the bend had become very sharp, the radius being only 1,200 feet, and the maximum depth of water off the shore had reached 50 feet. The mattress was in the water for a distance of 1,800 feet, 200 feet of it and the root still remaining on shore. The material forming the bank at the center of the work being very soft and easily eroded, it cut back so far as to necessitate widening the mattress by weaving a strip along the inner edge about 30 to 40 feet.

On the morning of May 21, it was found that a break had occurred during the previous night causing the mattress to be torn nearly into two pieces near the "slough." The break commenced about 500 feet farther up stream and widened rapidly to this point. The bank being exposed it cut away with such rapidity that the inner edge of the mattress dropped into the river.

The appropriation being nearly exhausted and the balance on hand insufficient to repair the break, I was compelled to allow matters to take care of themselves. The lower half of the work will probably be entirely destroyed before the present high-water is passed.

TARBOX POINT DIKE.

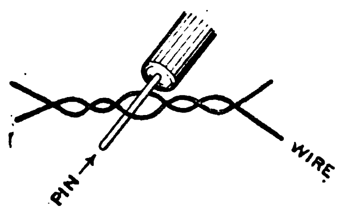
The preparatory work for the construction of the wire curtain dike at Tarbox Point was begun April 12. The work was stopped before the completion of the dike, owing to a scarcity of funds, yet enough was placed in position to insure the success of this sort of structure and furnish data for estimating its cost. The dike is essentially a wire screen of coarse mesh, having a width of 30 feet, and is held in place by weighting one edge with rock and supporting the other edge by buoys. The total length of the dike was 800 feet.

Two forms of meshes for the wire curtain were used, viz, the diamond shape, with diameters of 16 inches and 24 inches (the latter vertical), and the hexagonal with a shorter diameter of 10 inches. The method of making the former is shown.

No. 14 wires, wound on spools, were led over the top of a 24-inch drum into which pins were driven at the proper places for shaping the mesh. The strands were then brought together beneath the pegs and twisted securely, care being taken to cause each strand to travel continually along the drum in order to make each diagonal of the curtain from a single wire and not from the zigzag portions of several wires. The work was wound in a roll as fast as it was completed.

Four men are as many as can work to advantage at this frame, twisting, while one man keeps the spools filled with wire. The average day's work was 36 feet per each man employed, or 180 feet per day. Amount of wire per foot, a trifle less than one pound of No. 14.

The hexagonal mesh was the same as that used at Nebraska City, Nebr., during the fall of 1879. A sufficient number of wires were stretched on a horizontal frame and 10 inches apart and the meshes were made by bringing together at the proper place two of these wires adjoining each other and twisting them securely together by means of an iron pin, as shown by this sketch. The frame was provided with a sliding guide having staple for the wires to pass through, thus holding them in places while being twisted.



The frame for the curtain was 80 feet long by 30 feet wide.

Seven men with two boys to help will make and wind 400 feet per day. The amount of wire per foot of curtain is about 1¼ pounds of No. 14.

Each of these styles were furnished with selvage edge, made by twisting two No. 12 wires. The total average weight was about 1 pound to 30 square feet of curtain.

The buoys were pine boxes 12 inches square at the end and 2 feet long. They were made tight by marline at each joint and then were well tarred. In order to distribute the buoyancy as nearly uniformly as possible, these small floats were selected and placed 10 feet apart, giving a flotation of about 12 pounds per running foot, instead of using larger floats and concentrating the buoyancy.

The success or failure of the work depends upon the buoyancy of the upper edge and the effect produced by the loss of a small buoy is scarce noticed, while the loss of a large float where the buoyancy per foot of dike is the same produces a very bad result.

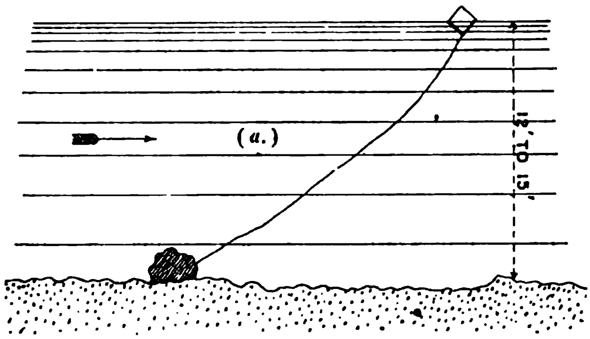
The anchors were pieces of rock, averaging 80 pounds each in weight, and were wired securely to the lower edge about 2 feet apart, thus obtaining a nearly uniform anchor weight throughout the whole length of the dike.

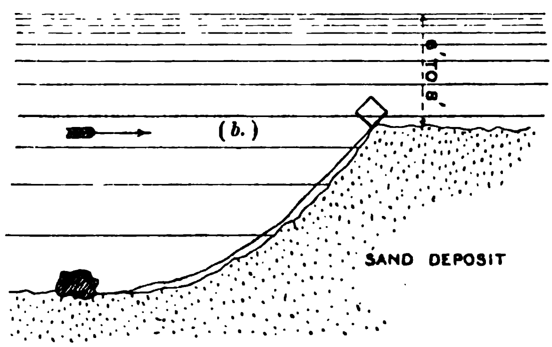
The method of constructing or placing the dike in the river is shown.

A line of anchors with barrel buoys were located immediately above the line of the dike, and by means of these and a capstan the barge was worked out from the shore with its gunwale always at right angles to the dike. The end of the curtain being securely anchored on shore, the roll being in the hold of the barge, the completed work was passed over the side as rapidly as men could wire rock to the curtain at the bow and buoys to it at the stern of the barge.

The work was designed to be sufficiently open so that the accumulation of roots, &c., in twenty-four hours would decrease the cross-section one-sixth, and to have a width of at least three times the depth of water. Owing to the very great amount of young willows floating beneath the surface and to the final location of the dike in somewhat deeper water than at first intended, these points were not reached. The first line of curtain was laid as shown in sketch (*a*). In twelve hours it had assumed the position shown in sketch (*b*), and the meshes were so completely filled with

willows, &c., that a pole could not be thrust through the mass, and it is doubtfu if a greater number of buoys would have changed the result.





Eight hundred feet were placed in this manner when it was thought advisable to lay a second line immediately over the first. Four hundred feet of this line were completed when work was stopped. This line was buoyed at intervals of from 5 feet to 8 feet, and had the same weight of rock per foot as the first.

Six hundred and fifty feet of the hexagonal mesh and 550 feet of the diamond mesh were used. No difference due to the size or shape of the meshes could be discovered except that the former was the stronger. The best speed made was 400 feet of dike by nine men in ten hours, and it is thought that under favorable circumstances 12 men can lay 1,000 feet of the dike per day.

The rapidity with which the meshes of the dike filled with submerged material was astonishing, so that the problem is really how to construct a dike which will *not* catch all of this material instead of one which will stop it all, as was at first thought desirable. This result can be obtained, I think, by using a long narrow diamond or hexagonal mesh which will allow a large proportion of the floating brush to slide up and over it, the longer diameter of the diamond being vertical.

The total cost of the work was $613.75, distributed as follows:

Rock	$202 72
Buoys	119 50
Curtain, including transportation, labor, &c	291 53
Total	613 75

Cost of diamond mesh curtain, per foot.

Making, including one-half foreman's time	$0.044
Transportation	0.016
Anchors	0.169
Buoys	0.099
Launching (many breaks occurred)	0.142
Wire	0.075
Total per foot of dike	0.545

Cost of hexagonal mesh per foot of dike.

Making, including one-half foreman's time	$0.031
Transporting	0.016
Rock	0.169
Buoys	0.099
Launching (no breaks occurred)	0.0425
Wire	0.100
Total cost per foot of dike	0.4575

The cost of making is based on the best day's work of each party.

The object of this dike was to throw the main river across to the Iowa side immediately above the point of the bar which made up from the head of Willow Island, thus shutting off the Willow Island chute and building the above bar back to the Nebraska shore.

A very large deposit occurred for a long distance below the dike, and could it have been extended to 1,500 feet, as at first intended, the desired result would have been secured. The water now sweeps around the end of the dike, having cut away the upper end of the bar, so that the discharge through the chute has not been decreased.

HYDRAULIC GRADING.

During the fall of 1879 the experiment of using a jet of water for the purpose of grading the banks, preparatory to placing woven mattress work upon them, was tried, and the results obtained, although the plant employed was far from being an efficient one, proved this to be beyond a doubt the cheapest and most satisfactory method yet employed.

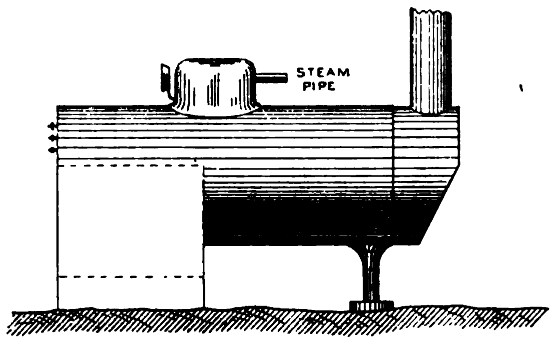
The plant consisted of a flatboat, 12 feet by 45 feet, containing a horizontal tubular boiler and a Blake special mining pattern pump, properly arranged for taking water from the river above the place to be graded and forcing it through a 2½-inch rubber hose. The entire cost of the outfit complete (with the exception of the flatboat) was $2,133.68, and the cost of working per day about $16.

It was proposed to carry on a series of experiments with a view of finding some method of using the water jet to remove bars or portions of the shore line, but the large amount of bank grading to be done did not admit of it.

The following is the principal data concerning the plant:

Stroke of pump	inches	12
Diameter of steam cylinder, area 113	do	12
Diameter of water cylinder, area 38½	do	7
Ratio of steam and water pressure per square inch		1 to 3
Single stream:		
Average piston travel per minute for 80 pounds boiler pressure	feet	200
Same for 70 pounds boiler pressure	do	160
Two streams:		
Average piston travel per minute for 70 pounds boiler pressure	do	224
Same for 60 pounds boiler pressure	do	200
Gallons per stroke (single) or per foot of travel	gallons	2
Maximum safe speed of pump per minute	feet	200
Maximum discharge per minute	gallons	400
Assuming 5 pounds loss between boiler and pump.		
Horse-power of pump for maximum discharge:		
Using one stream	horse-power	51
Using two streams	do	37.7
Diameter of boiler		3' 9
Length of tubes		3' 2
Diameter of tubes, average		1
Number of tubes		156
Width of grate		3' 4"
Depth of grate (lowest tube 5" above grate bars.)		3' 6"
Dome:		
Diameter		2' 6
Height		72
Steam pipe		1½
Exhaust pipe		2"
Suction pipe		4"
Total heating surface	square feet	167
Horse-power, using 12 square feet per horse-power		14

Assuming mean effective pressure in steam cylinder at 75 pounds per square inch, the pressure in the water cylinder becomes 225 pounds per square inch (approximated).



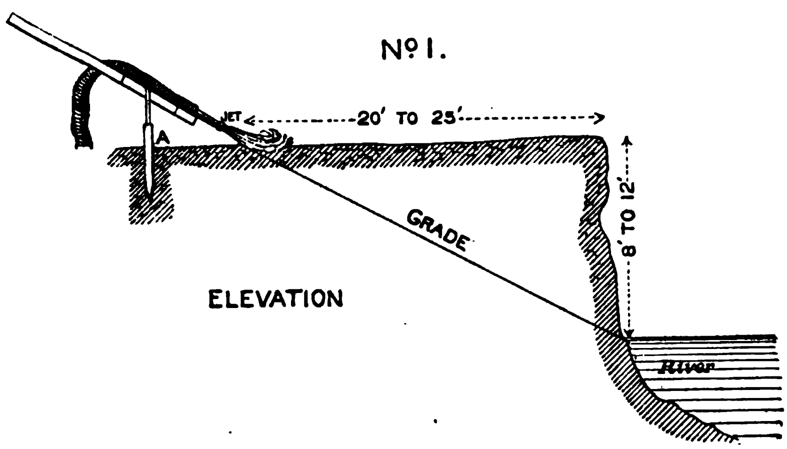
SKETCH OF BOILER

The frictional resistances in discharging 450 gallons water per minute through 100 feet rubber hose, $2\frac{1}{2}$ inches in diameter, being 60 pounds per square inch (see work done by and power required for 5 streams, Ellis), and assuming 5 pounds per square inch resistance in the pump, the pressure at the nozzle becomes 160 pounds per square inch, or about 10 pounds less than the theoretical pressure necessary to discharge the same amount of water through the same size orifice. With this quantity of water, at the pressure stated, it was found that the maximum effective cutting distance was from 15 to 18 feet, with the best form of nozzle to be obtained in this vicinity. On the highest banks, 12 feet, where the slope is nearly 30 feet, this stream was not sufficient to do the work without moving the stream down the slope to a point nearer the material to be moved, and the quantity of water was not sufficient to soften and carry away the material as rapidly as it should. The best results were obtained by using a 1-inch ring nozzle, made by setting a nipple of 1-inch gas pipe, $\frac{3}{4}$ inch long, into the orifice of a $1\frac{1}{4}$-inch smooth brass nozzle. This form was found to give a stream which would hold together for a greater distance than one given by the ordinary 1-inch ring nozzle.

A smooth-bore nozzle gave no satisfactory results, though several were tried, the sizes varying from $\frac{3}{4}''$ to $1\frac{1}{4}''$.

The method of working the jet from the flat-boat was found to be impracticable, and that a uniform grade could not be obtained in this manner. The method adopted, after trying all that could be thought of, was as follows, and is shown by the sketches.

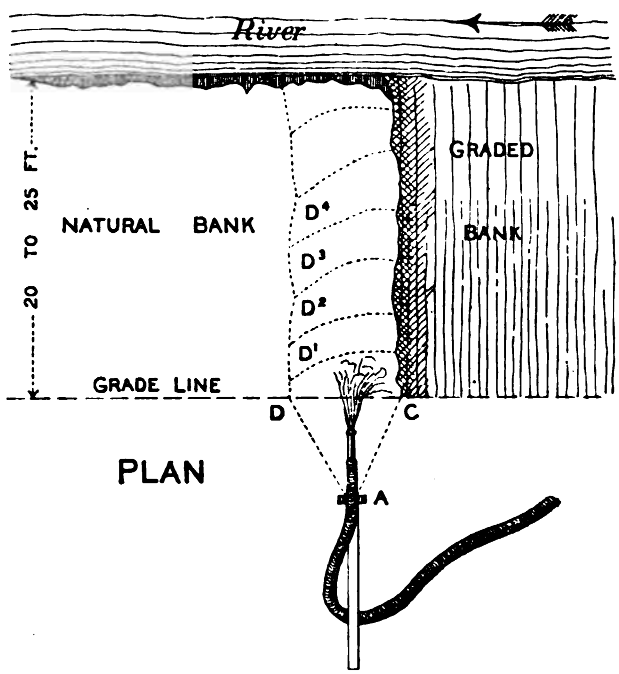
No. 1.



ELEVATION

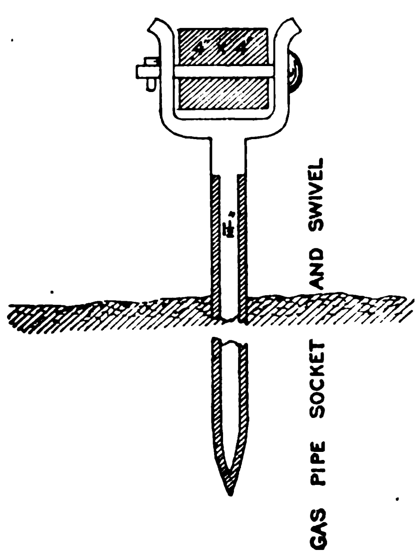
The grade line being run, a pointed gas pipe socket 3 feet long (by 1¼ inches diameter inside) is driven into the ground, about 3 feet back of it, and into this is put the pin

No. 2.



of the swivel on the lever, which is attached to the nozzle. The swivel and socket are shown at sketch No. 3. The nozzle being at the proper place, the jet is directed in such a manner as to cut a narrow channel down to the grade, and all the surplus earth washed into the river. This being done another socket is driven, as shown in sketches No. 1 and No. 2, that is about 3 feet back of the grade line, and about 3 feet further along it. Then the nozzel-lever is shifted from its previous position by three or four laborers without stopping the pump, and the socket drawn and located for the next position of the nozzle or the next section to be cut away.

No. 3.



As soon as the socket is in place the jet is directed against the ground at C (sketch No. 2), and worked along the grade line to D, being moved slowly back to C occasionally, to wash away the material cut away by the jet.

Slices of the bank are then cut out as along the dotted lines shown, care always being taken to have the face of the cut perpendicular to the direction of the jet by cutting well under it at the points D, D¹, D², D³, &c., before directing the jet to any other part of the face, except to break up and wash away the fallen material.

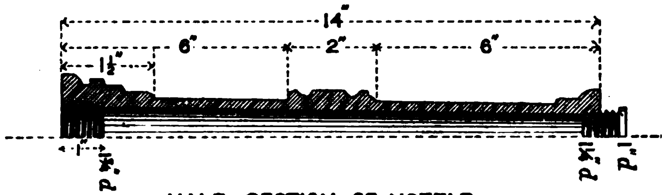
In order that the desired result may be reached with the minimum amount of work, it is necessary to hold the jet carefully down to the grade, and to do *all* the cutting and undermining at the very lowest point.

On long slopes it is often necessary, particularly where the material composing the

bank is clay, or is filled with roots, to drive a socket part way down the grade, and thus establish an intermediate cutting station.

An average day's work, when there are no unusual stops made, is the grading of about 100 feet of shore, and moving from 5 to 6 cubic yards of earth per foot, or from 500 to 600 cubic yards of the ordinary bank material.

No. 4.



HALF SECTION OF NOZZLE

Where the material is a light loose sand, this amount can be increased even with the inefficient plant employed to 800 or 900 cubic yards, while in tough clay, filled with willow roots, it is often very difficult to break up and remove over 300 cubic yards. The above results were obtained, using one jet and not working full time, owing to the inefficiency of the boiler, which with the utmost forcing could not maintain the 80 pounds, steam pressure required, and to the small size of the boiler tubes (1 inch in diameter) rendering it necessary to clean them often, as many as four times per day.

The coal used (Des Moines, third vein) burns well in boiler having 2¼ to 3-inch tubes, the usual size in this vicinity, but no satisfactory results could be obtained using one-inch tubes.

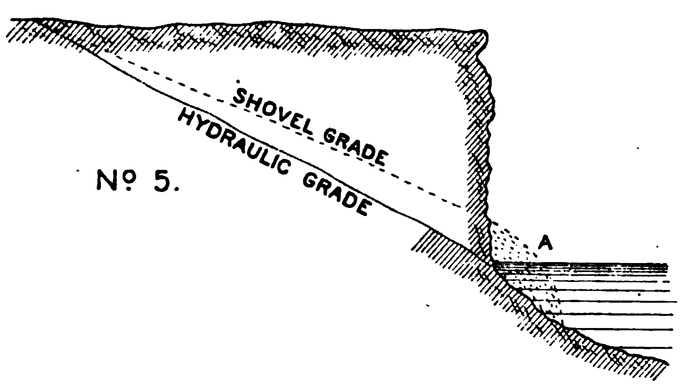
Taking into account all delays from boiler cleaning, bursted hose, &c, not over three-fourths of the time was spent in effective working.

With an efficient boiler and hose of sufficient strength, the effective work could be made more than double the results obtained, and I am confident that with a carefully designed plant the cost of grading banks can be reduced to less than 2 cents per cubic yard as an average.

The actual average cost for the whole season, including time for mounting, for repairs, and for dismantling was for labor 4.1 cents per cubic yard, and for fuel 1.15 cents per cubic yard, or a total cost of 5.25 cents per cubic yard.

Daily average taken while working in the lighter soils, showed a cost of from 2¼ cents to 2½ cents per cubic yard, after allowing for repairs and for interest on the investment. In the stratified sands and clays, the cost was from 3 cents to 4 cents per cubic yard. At Gumbo Point, where the material was a tough, firm clay, completely filled with willow roots, and where an unusually flat slope was given, the cost varied

No. 5.



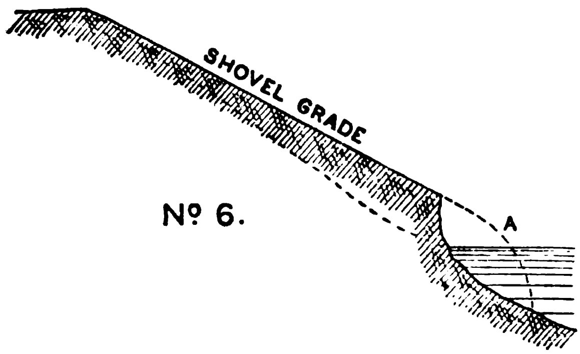
from 6 cents to 8 cents per cubic yard. At this latter place it was estimated that the same slope could not be obtained by the use of pick and shovel, at less than from 15 cents to 18 cents per cubic yard.

Upon two occasions comparative trials were made to determine the relative economy of the two kinds of grading, extending over several days. The ground selected was

very uniform throughout, and somewhat better or easier to work by hand than the average banks are. The cost per yard, net, for the work done by the use of picks and shovels was 6¾ cents. The cost by the hydraulic method was 3½ cents per yard, a trifle over one-half.

The shovel grading was thus about 28 per cent. greater than the average for the season as given above, 5¼ cents.

If the mattress work is up close to the grading, so as to be placed on the slope immediately, the above is a fair average cost of shovel grading, but it is oftener the case that the two kinds of work are several days apart. When this state of affairs exists the superiority and economy of the hydraulic work is apparent.



Nº 6.

Sketch No. 5 shows the relative conditions of the two kinds of grading. In grading by shovel a bank of earth is rapidly built up at the foot of the slope at "A," so that the slope never coincides with the one desired, but is flatter until the water line is reached, when there is a sharp reversed curve to reach the natural slope under water. The bank thus built up is very soft and will not support a man's weight or stand the wash of the current or waves, so that in a few days the bank assumes a shape shown in sketch No. 6, having a bluff bank from 2 to 3 feet high at the foot of the slope. necessitating regrading, often at a cost of from 5 cents to 8 cents or 10 cents per foot of shore. The slope when reached by the hydraulic method is firm and hard and all the surplus material is dissolved or softened up and washed away from the foot of the slope. The bank at the water's edge thus approaches the nearest possible to the natural slope under water, and is thus made less liable to be cut away than the natural bank. This advantage is apparent both before the mattress is placed and after, and the condition of the bank for insuring good work is marked as to cause one to favor the hydraulic grading, even at a greater cost.

It soon became evident that the plant was entirely too small to do the proper amount of work of grading, but more especially so for the work of cutting the shore line back any distance or for making an appreciable effect on bars.

To keep entirely ahead of the mattress work the capacity should be at least 300 feet per day or about three times the capacity of experimental plant. The quantity of water thrown (400 gallons per minute) was not sufficient to saturate the material in the case of sand or to soften and break up the large lumps of clay, and also wash them into the river. In sand the volume should be sufficient to at once form a fluid mass which would run quickly from the grade. Careful observation during the progress of the work led me to decide that the quantity of water thown in this soil should be from 2 to 2½ times the above amount or from 800 to 1,000 gallons per minute. This amount would carry off sand and loose material as rapidly as it could be undermined.

The cutting effect of this jet was about sufficient for sand, but was not so for the harder and tougher material found. With such an increase in the quantity of water thrown, the cutting effect at the same nozzle pressure (160 pounds) would be largely increased, but as this in clays depend almost entirely upon the intensity of the pressure or impact and not so much upon the quantity of water thrown, I would suggest that in any apparatus devised for this purpose, the nozzle pressure be increased to about 200 pounds per square inch.

Two of the next larger size of this same style of pump working to a common air-chamber, would probably be ample for grading any bank when worked to their full capacity. The air-chamber should be very large. This is a fault common to nearly all of the smaller steam pumps, that the air-chambers are insufficient and that the pulsations are carried the full length of the hose.

In this character of work where the hose has to lie on the ground, the pulsations

should be prevented, as the constant moving of the hose soon wears a hole through it or thins it sufficient for the pressure to burst a hole through.

A plant of this sort is of great value for numerous other things besides the work for which it was designed, and by increasing its power to that indicated above and by supplying it with a proper boiler, I am confident that ordinary river banks may be graded by it at a cost of little over 1 cent per yard.

Respectfully submitted.

CHESTER B. DAVIS,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 14.

IMPROVEMENT OF MISSOURI RIVER BETWEEN OMAHA AND PLATTSMOUTH, NEBRASKA.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 30, 1880.

GENERAL: In compliance with your instructions of the 9th ultimo, I have the honor to submit herewith a copy of the map of the Missouri River between the railroad bridges at Omaha and Plattsmouth, Nebr., recently made under my direction, and also a copy of a report of my assistant, Capt. Thomas H. Handbury, Corps of Engineers, U. S. A. giving plans and estimates for the improvement of the navigation of the river between the points mentioned.

For details, I beg to refer to the accompanying report and map. The situation in brief is this: The portion of the Missouri River under consideration is extremely tortuous and has a heavy slope, averaging $\frac{8}{10}$ of a foot to the mile. The banks are very unstable and are subject to great erosion, the result of which is an excessive width of waterway, with ever-shifting channels and small navigable depth. The incessant erosion on the narrow necks between bends has already caused two cut-offs, one at Omaha and another at Saint Mary's, a few miles above the mouth of the Platte, and several others may be soon expected if measures are not taken to prevent them. The effect of cut-offs is to greatly increase bank erosion in the neighborhood and to impair the navigation over considerable distances. It is also desirable that a stable regimen be established throughout this stretch of river, as any changes here would have a very prejudicial effect upon the works of improvement now in progress at Omaha, above, and Nebraska City, below.

The plan proposed by Captain Handbury, and which is approved by me, contemplates the protection of such banks as are exposed to erosion and a partial rectification of the channel, by the use of methods and appliances similar to those successfully used under my direction at many other points along the river. The estimated cost is as follows:

For revetting 180,000 feet of shore line, at $2.25 per foot	$405,000
For constructing 20,000 feet of brush dike, at $1 per foot	20,000
Add for superintendence, surveys, cotingencies, &c	75,000
Total	500,000

Of this amount $200,000 could be advantageously expended in one season, and it is important, in order to carry the work to completion with economy and dispatch, that the appropriations for the work should be made in liberal sums.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN THOMAS H. HANDBURY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 28, 1880.

MAJOR: In obedience to your verbal instructions received a few days since I have the honor to submit the following report upon the condition of the Missouri River between Omaha and Plattsmouth, Nebr., together with a plan and estimate of the probable expense for improving the navigation of the same between these two points.

The length of the river following the channel line included between Omaha and Plattsmouth is about 29 miles, with an average slope of $\frac{8}{10}$ foot to the mile. The width of the valley throughout this extent will average about 4 miles. Its soil is in general a light alluvium that has been washed down in former years from the upper regions. Through this the river flows with a rapid current in constantly changing channels.

Evidences everywhere exist, not only in this special locality but throughout the whole extent of the Missouri River Valley, that in past ages the river has with more or less periodic regularity changed the location of its bed from one bluff to the other and then back again, moving, in this change, the whole of the enormous amount of soil that lies between; and this operation is still going on, as is manifest by the erosions that are taking place and the constant disappearance into the waters of the river of acre after acre and farm after farm of the most productive land in the world.

So long as this region was in a state of nature it made but little difference what changes took place or what was the result of the contest that was going on between the natural forces. The river might then travel back and forth between the limits of its permanent barriers as often as it pleased, and move that which was in its course whenever and wherever it liked, but when civilization appears upon the scene, with its steamboats and railroads and bridges and agricultural interests and habitations for the comfort and convenience of man, then it becomes necessary to check these erratic wanderings and to prescribe some reasonable bounds within which it must be restricted.

A large river like the Missouri, with a slope as great as that which it has, and draining, as it does, many thousand miles of territory, will maintain a velocity sufficiently great to cause perpetual erosions in the light alluvium through which it flows, the extent of which will vary according to the impact of the current, and the more or less compactness of the soil forming the river banks. Under this action, where the circumstances are favorable, bends will be formed, and not unfrequently they will take the shape of loops, with narrow strips of land separating two portions of the river that are several miles apart when measured along the channel. When these narrow strips are washed through, cut-offs take place, which shorten the course of the river, change its slope, increase its velocity, and otherwise disturb its regimen for many miles both above and below. Increased erosion takes place, navigation is impaired, interests along the banks are jeopardized, a different course is given to the river, new bends are formed, and the foundation laid for a repetition of the same series of events at some future day. This action, in its intensified form, is illustrated in the reach under consideration perhaps as forcibly as in any other of a like extent that could be selected throughout the whole course of the river.

To be more specific, let us look a little into what has taken place here only within the last few years. After the Omaha cut-off took place in 1877, the regimen of the river for many miles both up and down was very much disturbed.

This event gave it a tendency to come close to the foot of the bluff along the Omaha front. The light sand, of which the bottom land here is composed, offered but little resistance to this tendency; but there being large interests dependent upon its preservation, it became necessary to protect it from the erosive action of the river. The Union Pacific Railway Company expended large sums in protecting their repair shops and other interests that are located here, and Congress made liberal appropriations, which have also been expended in this locality in the interests of navigation. Had the river not been held in check, there is no doubt but by this time the whole of the bottom land in front of Omaha below the cut-off would have been washed away, together with the car-shops, smelting-works, and all other establishments that are built upon it, to say nothing of the injury that navigation would have sustained. The safety of the bridge, too, would have been seriously compromised. With the river close along the foot of the bluff in this vicinity, its tendency would be to leave it at the western abutment, if it did not succeed in washing it away, and, impinging against the opposite bank below, would cause erosion to take place. In this immediate vicinity the conformation of the ground is such that this action would soon bring about another and quite extensive cut-off. Even now, with the work of improvement in successful operation above the bridge, there is a decided tendency in this direction.

By consulting the accompanying map the situation below the bridge can be seen at a glance. In the bend at Council Bluffs lower landing extensive erosion has taken place, and the river bed has been widened to such an extent that it is difficult at

times to find a navigable channel. The neck of the peninsula opposite this bend, it will be observed, is very narrow, with the channel line close up to the bank upon either side. Erosions are taking place here at a rapid rate, which, if not checked, will soon result in a cut-off. In Saint Mary's Bend, the next below, one of these has recently taken place. The results are anything but favorable either to navigation or to the interests centered along the river banks and upon its bottom lands. The old town of Saint Mary, that was once upon the mainland, in the State of Nebraska, is now an abandoned site upon an island and constructively in the State of Iowa. The river is yet in a very unsettled condition. Erosions are taking place upon all sides and many acres of the finest land are daily being washed away. Just below the lower end of this cut-off the current impinges violently against the Nebraska shore, with a fair prospect of cutting a way for itself into the bed of the Platte. Should this be effected the situation would be complicated in the extreme.

At the town of Plattsmouth, where a railroad bridge is now in process of construction, the available water-way has been contracted by means of dikes to within a width of 1,000 feet. Any disturbance of the position of the channel in this vicinity is liable to result in washing these dikes away, an event that would be very disastrous to the bridge, as its eastern piers, I am informed, do not extend down to the solid rock foundation. To satisfy all the conditions that demand attention in this locality will be the most difficult part of our problem to solve.

This, then, in a few words, is the general condition of the river to-day between Omaha and Plattsmouth: a swift-flowing stream, with eroding banks and constantly changing channels, carrying downward in its course, either in suspension or rolling along its bottom, thousands of tons of sand and soil.

In the lakes, swamps, and lowlands to be found almost everywhere throughout the whole extent of the valley, we have unmistakable evidence that as the river is to-day so it has been for ages past, its peregrinations limited only by the bluffs that bound the valley in which it runs. Unless restricted in some way, it is only a matter of time when the mortgage that the river is said to have upon every portion of its bottom land will be foreclosed.

Under the new dispensation that is hereafter to have the governing influence upon the valley, there are certain modifications necessary to be made in the old condition of affairs to suit them to the new interests that have arisen.

In the interests of navigation, channels must be provided having the requisite depth of water for such boats as are found most economical for the transportation of the freight that is to be moved by water. In the interests of agriculture and of those great railway lines that run along the river banks, and are such an essential feature in transporting the products of the soil, and communicating between the different parts of the country, the erosions must be stopped and the width of the river bed restricted to such limits as will suffice for its needs and no more.

That these results can be obtained within reasonable limits of expense we have every reason to believe, judging from the experience already gained in improving those limited portions of the river for which Congress has already made appropriations.

Since the principal source of all these evils that we are seeking to remedy lies in the fact that the velocity of the current is too great for the tenacity of the soil composing the banks to withstand, it is evident that all our efforts should be directed to diminishing this velocity and protecting the yielding banks.

To diminish the slope, the course of the river should be lengthened wherever practicable, and cut offs should be prevented by every possible means in our power.

The most destructive erosions take place during the falling stages of the water. The foot of the bank is first attacked, and when the material, usually sand, is washed away, the upper portion, being unsupported, tumbles into the water. This eroded material is carried down either in suspension or rolled along the bed of the river. As the current from time to time is checked either by a diminution of the slope or by meeting some obstacle in its course, the material *in transitu* is deposited and for a time at least brought to rest.

These depositions, in their turn, change the course of the river, and cause its current to impinge against the bank in some new locality farther down. Thus the operations go on day after day and year after year.

To effect the desired improvement, what is needed is a judicious combination of two kinds of works—one to cause depositions and deflections in desired localities, and the other to receive the impact of the current where it impinges with destructive effect against the bank, and to check the erosion where it is desirable to do so. By these means it is possible in time to lead the river, as it were, through this bottom land, and hold it in any reasonable position that we may select; but in attempting this we should bear in mind that there are certain fundamental hydraulic principles that we must not transgress.

On the accompanying map, which is a reduced copy from the advanced sheets of the Missouri River survey now being made under your direction, by your assistant, D. W.

Wellman, I have endeavored to trace out a course that I think it possible to cause the river to take, and practicable to retain it at an expense commensurate with the importance of the interests involved, and which will be a satisfactory solution of the problem under consideration.

In laying down these lines I have assumed that a width of from 1,500 to 2,000 feet will be about the proper limits within which to keep the waters of the river in order to insure a navigable depth during the low stages and a sufficient water-way during the high. The directions are those that I think can be attained and retained within the most reasonable limits of expense.

For causing deposits to take place, and for deflecting the current in these localities that are to be built out, I would recommend the use of floating brush obstructions such as have been applied with such marked success at the various places along the river where works of improvement are in progress under your direction. The most successful of these may be briefly described.

The floating brush dike is made by taking saplings from 20 to 30 feet long and from 4 to 6 or 8 inches in diameter, and nailing or fastening to them with wire scraggy brush of any kind that may be obtainable in the locality. This forms what is known as the "weed." Instead of the saplings rope may be used to which to fasten the brush. To one end of this "weed" is attached an anchor of sufficient weight to hold it in position against the current; to the other a buoy that holds up the downstream end and prevents it from going to the bottom under the pressure of the current against it.

These "weeds" are placed in the river in the desired locality at a distance of from 10 to 20 feet apart, thus forming the floating dike.

Their action is to check the current gradually without producing that scouring effect to which the solid dike gives rise. This done, a portion of the material that is rolling along the bottom or being carried down in suspension is deposited and causes a rise in the bed of the river which changes its channel into the direction desired. The rapidity with which these deposits take place is truly wonderful. One season is often sufficient to raise the river-bed up to the limits of ordinary high-water.

Another form of obstruction that has been tried with success is the willow curtain. This, as its name indicates, is made of willows about an inch in diameter or larger, fastened parallel with each other and from 6 to 8 inches apart, by means of wire. The curtain can be made of any desired length and width. They are anchored in position by weights attached at intervals along the lower edge and held in an upright or inclined position in the water by floats made fast to the upper. Their action is similar to that of the weeds.

Another form that has been experimented with and which bids fair to give good results, is a screen made totally of wire something after the fashion of a seine. It is anchored and buoyed like the willow curtain. The rootlets and small vegetable fibers that are floating in large quantities in the water accumulate upon the wires, and form obstructions sufficient to check the velocity of the current.

Still other forms have been tried with more or less success.

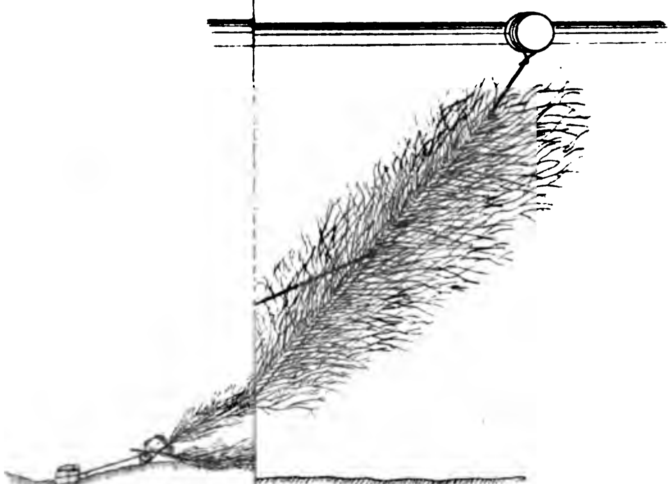
For resisting the impact of the current and preventing the erosion of the banks, a variety of devices have been tried with more or less success. Among the most satisfactory of these may be mentioned the woven brush revetment, the continuous mat, or brush-blanket, made of brush, sewed together with wire, and the willow screen, made as above described, for the willow curtain, excepting that the willows, instead of being placed some inches apart, are as nearly as possible in juxtaposition. The manner of using either of these devices is the same. The bank to be protected should first be graded to a slope of about 2 upon 3 or less, an operation that can be very cheaply performed by the use of hydraulic force-pumps, after which the revetting should be put on so as to extend from the ordinary high-water limit down the bank and out along the river-bed sufficiently far to protect the slope should any unusual scour take place. The total width is usually in the neighborhood of 100 feet. To sink that portion which is under the water, a small quantity of rock is sometimes necessary, but usually the current itself and the sediment that collects on the brush will suffice for this.

The effect of this revetment is to thoroughly protect the bank over which it is placed, and to cause a deposit of sediment over itself that crowds the current away from the bank towards the middle of the stream.

In proportion to the results obtained, these are certainly the cheapest devices for improving rivers of a sediment-bearing character that have as yet been tried.

For the revetment of the banks I estimate that $2.25 per foot of shore line, or about $12,000 per mile, will be sufficient, and for the dikes $1 per running foot.

As nearly as can be estimated at present, there will be between the Union Pacific Railroad bridge at Omaha and the bridge at Plattsmouth, approximately, 180,000 feet of shore line to be revetted, and 20,000 feet of floating brush-dike or curtains to be made. These numbers cannot be given with accuracy, because of the changes that are constantly



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taking place; but assuming them as a near approximation, the estimate for puttting this reach of 29 miles in a good navigable condition, and at the same time securing all other interests located here from the encroachment of the river, will be about as follows:

For revetting 180,000 feet of shore line, at $2.25 per foot	$405,000
For constructing 20,000 feet of brush dike, at $1 per foot	20,000
Add for superintendence, surveys, contingencies, &c	75,000
Total	500,000

Of this amount, $200,000 could advantageously be expended during the coming fiscal year.

It is scarcely necessary to add that the circumstances of this case are such as to require that the necessary funds for carrying on the work should be appropriated in considerable sums if econimical results are to be arrived at. It can easily be seen how the work of a season can be rendered nugatory by some sudden change of the river if funds are not constantly available for every emergency.

Respectfully submitted.

THOS. H. HANDBURY,
Captain, Corps of Engineers.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 15.

IMPROVEMENT OF MISSOURI RIVER AT SIOUX CITY, IOWA.

The work described as in progress in my last report was continued during the season as far as the available funds would allow. The main work was done on the Nebraska shore, where the danger was greatest. The revetment already begun here was extended down stream 2,000 feet, with an average width of 69 feet, and a weed dike was commenced. After extending it out 300 feet into the stream it was deemed advisable to abandon it for the time, in order to leave more money for the revetment. The work has on the whole stood very well, but there is very much more work required, and the ultimate cost will certainly be greatly increased unless larger appropriations are made.

It is proposed to expend the present appropriation in extending the work in accordance with the general plan, with a view of contracting and regulating the water way so as to remove obstructions to navigation and give a good landing at all seasons at Sioux City.

The appended report of Assistant S. H. Yonge, who had charge of the work, will give full information concerning the methods of construction used.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$6,912 99	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$14,912 99
July 1, 1880, amount expended during fiscal year		6,511 65
July 1, 1880, amount available		8,401 34
Amount (estimated) required for completion of existing project		15,800 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		15,800 00

REPORT OF MR. SAMUEL H. YONGE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *February* 21, 1880.

MAJOR: I have the honor to submit the following report of operations conducted during the present fiscal year on the work of improvement of the Missouri River at Sioux City, Iowa.

During the month of July, 1879, the river continued to encroach on the Nebraska shore, from the point above Covington, for a distance down stream of about 3,800 feet. The greatest erosion amounted to 200 feet, and was situated about 2,300 feet below the point. At the point and for a distance below of about 300 feet, where the continuous mat revetment had been constructed the month of May previous, the bank was successfully held, although the work had been built during a high-water stage, and in consequence the sloped face of the bank was too short to afford a perfectly secure anchorage for the shore edge of the mat.

After the water had receded an inspection of the portion of the mat on the bank showed that it was well filled with silt. This deposit lay principally in the lower meshes of the mat, and was from one-third to one-half of the mat's thickness. The upper layers of meshes were generally clean of silt, though in places the mat was entirely filled. Sounding with a rod proved that a similar state of affairs existed below low-water, where the top of the deposit was situated, as near as could be measured, 6 inches below the upper surface of the mat. No scour appeared to have occurred underneath the mat, its pliability probably counteracting this action by immediately filling any voids.

From these data it might be inferred that under similar circumstances the minimum thickness of revetment built on this system for low-water protection is 6 inches, and for bank protection 3¼ inches, as at these depths beneath the top surface of the mat the flow of water was sufficiently retarded to cause the silt with which it was charged to be precipitated.

The bottom velocities in the vicinity of the work, as near as could be obtained, were from 5 to 8 feet per second. It is possible that this form of matting, 3 inches in thickness, would serve as a protection against currents of high velocity, but the margin of safety, if any, would be very small, and it could not be expected that the thinner mat would accumulate silt in its lower meshes and become so firmly imbedded as a mat of greater thickness.

An important precaution to be taken in constructing on this system is that of giving the mat sufficient strength by a proper thicknees to prevent its pulling apart, and to withstand the strains produced by strong currents while lying in the water before sinking, the process of weighting it with rock and the action of whirls. Present circumstances indicate that a thickness of 12 inches is sufficient for a mat extending 50 feet from shore; this thickness is equivalent to six-tenths of a foot, solid measure.

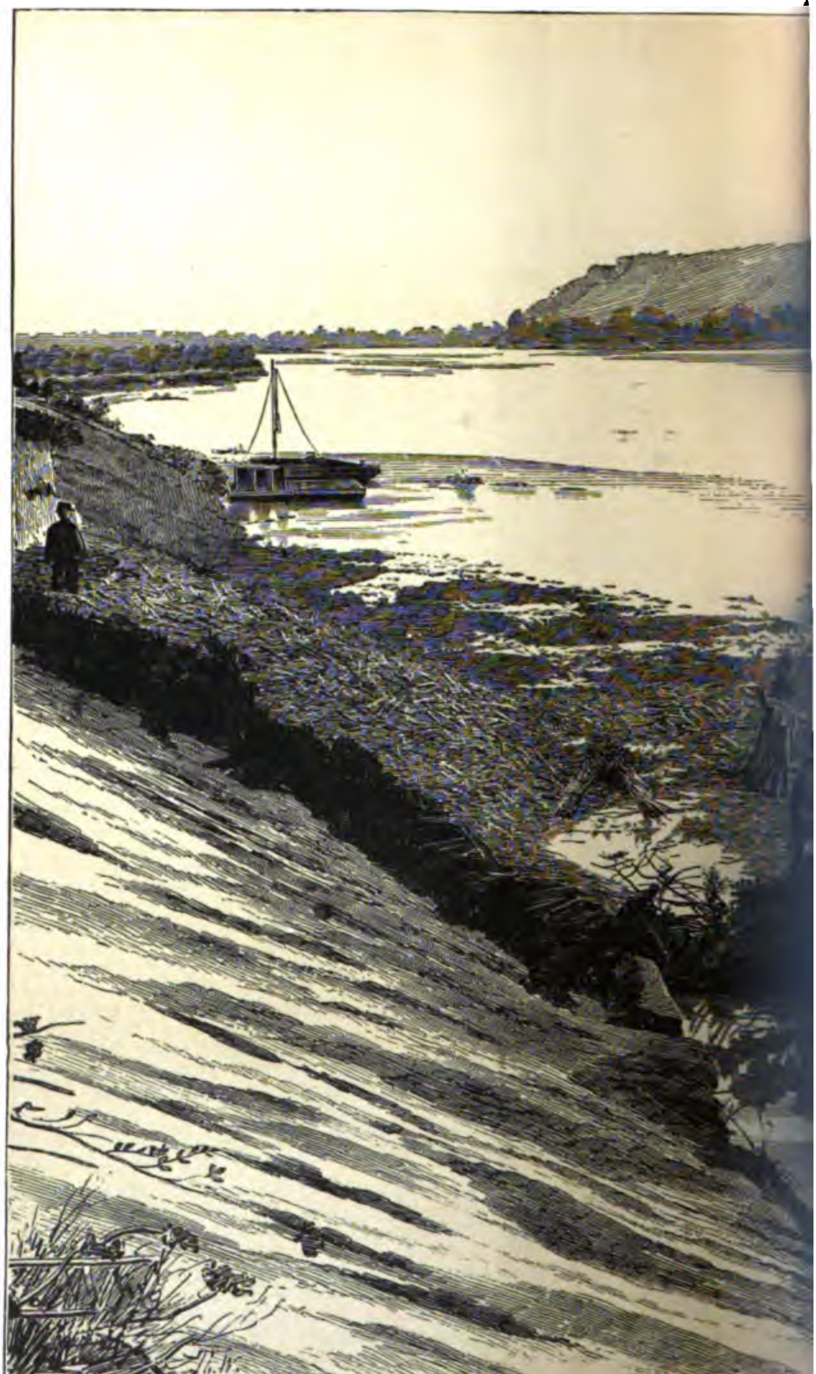
For a distance of 6 feet above low-water line the mat should be at least 12 inches thick, so as to break the force of the waves raised by high winds and passing steamboats, which would cause the toe of the bank to slough out and eventually destroy its outline.

On account of the erosion along the Nebraska shore, before alluded to, a corresponding shoaling appeared imminent along the Iowa shore in front of Sioux City; owing to the continued stage of high-water, however, measures could not be taken to prevent this action until July 22, when a floating weed dike was begun at Nebraska Point. Though the efficacy of the dike was under the circumstances to a certain extent a matter of conjecture, the case was one that warranted the employment of even doubtful measures. For a distance of 2,000 feet above where the dike was located, the channel followed the shore of the Willow Island, which consists of a tough blue clay, and impinged with great force on the revetment at the point, which gave it a tendency to cross the Iowa shore.

The greatest depth of water on the section of the projected dike was 16¼ feet, at about 50 feet from shore; this depth gradually decreased to 14 feet, at about 500 feet out.

The surface velocity varied from 8 to 10 feet per second during the construction of the dike. The weeds were made by attaching bunches of dogwood brush at intervals of from 2 to 6 feet, on a three-fourths-inch line, from 45 to 60 feet in length; the buoys consisted of coal-oil barrels.

Some trials were made with cottonwood boxes filled with broken rock as anchors. The boxes were at first made to contain 1,400 pounds of loose rock; this weight proving inadequate for the purpose, the size of the box was increased so as to have a capacity of 3,500 pounds; this size was also found insufficient to hold the weeds to an anchorage, and the arrangement was abandoned. Anchors were also made by bending flatwise a piece of bar iron 4 by $\frac{5}{16}$ inches into a circular shape, 4 feet in diameter, a few sacks filled with broken rock were attached around the band to cause it to bury in the sandy bottom more rapidly. The results with this form of anchor were not satisfactory. This was probably due to the insufficient width of the iron used, and no wider



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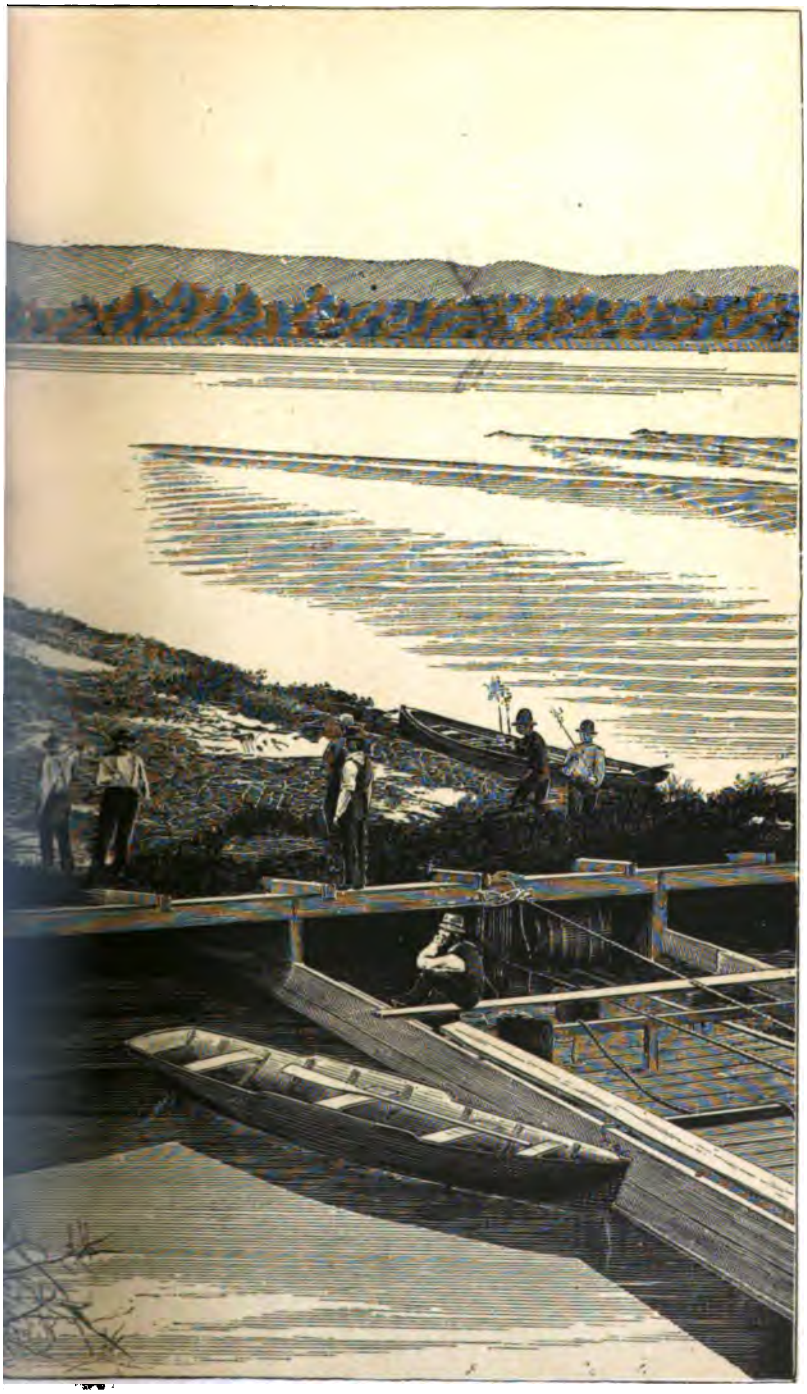
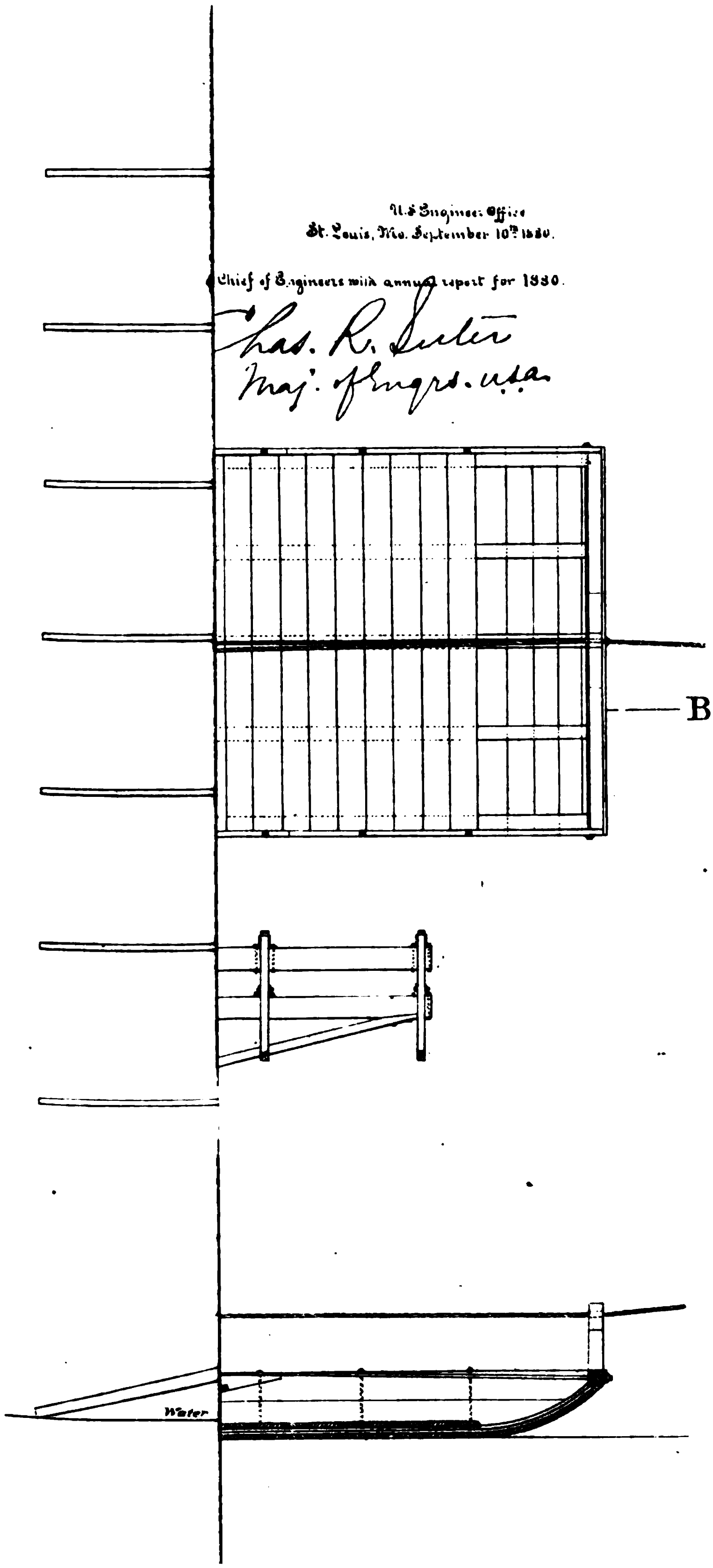


IVER—SIOUX CITY, IOWA.

N MATTRESS—LOOKING UP STREAM.


U.S. Engineer Office
St. Louis, Mo. September 10th 1880.
Chief of Engineers with annual report for 1880.
Chas. R. Suter
Maj. of Engrs. U.S.A.
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Water

iron was at the time obtainable. Sacks filled with rock were finally used altogether; the number and sizes attached to a single weed varied from 20 3-bushel to 24 4-bushel sacks.

The weeds were placed in position from a flatboat 14 by 40 feet, swung from an anchor placed about 200 feet up stream; they were spaced not less than 10 feet apart.

A great many weeds without buoys were distributed over the bed of the river in the line of the dike and above it, to prevent scour and hasten a deposit.

After the dike had been carried out a distance of 300 feet from shore, it was found that owing to the difficulties of construction its cost was greatly exceeding the estimate; and further work on it was discontinued, with your approval, on August 15. Its cost was $3 per linear foot.

The effect of the dike was noticeable in distributing the currents and thereby lessening their force along the Nebraska shore for a distance of 600 feet below.

About the middle of September an accretion from 6 to 10 feet thick, extending 45 feet from shore and 200 feet in length, rapidly formed above and below the dike.

As there was every probability of a further encroachment occurring on the bank above Covington, in subsequent floods, the plan laid down for the season's work was changed, and the part of the project which embraced the revetment of the Nebraska shore was undertaken on account of being the most urgent.

This work was begun on the 26th of August, and was completed September 22. It consisted in building a continuous woven mattress 2,000 feet in length with an average width of 69 feet. The thickness of the mat below the water line was 12 inches; on the bank, 6 inches.

In weaving and launching the mat, the same boat and frame were used that had been built for this purpose the previous summer, a drawing of which accompanies this report. The up-stream end of the mat overlapped the revetment at the Point 50 feet.

The bank to be protected consisted of layers of very fine sand, and caved rapidly when exposed to currents of ordinary velocity.

The elevation of the top of the bank was 20 feet above low water, with an almost vertical face. The bed of the river sloped from the foot of the bank with an inclination of 3 horizontal to 1 vertical for a distance of 40 or 50 feet from shore, where the water attained its greatest depth.

Between the elevations of ordinary high and low water, the bank sloped to an angle of 29°. The mat extended from the top of the slope to a distance of 40 feet out from the water line. In building the mat the workmen were placed 8 or 9 feet apart in a line at right angles to the direction of the bank, and were kept supplied with brush by laborers hired at a lower rate of pay. The bundles of brush were laid on wooden horses placed on the mat; this was found to be advantageous, as the brush was handled with greater rapidity if kept dry. The brush used was of uniformly good quality; it consisted of green willows from 10 to 20 feet in length, sorted and tied up in bundles about 10 inches in diameter; it was delivered on the river bank at the work for $1.60 per cord.

During the progress of the work large tree stumps were frequently found beneath the water surface near the bank. Some of these stumps could not be removed without delay to the work and considerable expense, and it was not deemed desirable to build over them in cases where they were standing upright. To overcome this difficulty an opening of proper size was left in the mat in each case, so that when it was sunk the stumps would not form an obstruction to its lying evenly on the bottom. The edges of these openings were selvaged to prevent raveling. The outer edge of the entire mat was also secured by turning in the brush and making a heavy selvage. The greatest care is necessary with this part of the mat; if imperfectly done the work is liable to ravel and pull apart. At the lower end of the work, for a length of 70 feet, where there was some danger to be apprehended from the effect of eddies, during high-water stages, the whole height of the bank was sloped and the matting carried back over the top. After the revetment was completed, the upper part of the bank which had not been sloped was thrown down on the matting above the water line, with the principal object in view of causing the willows to grow, although the brush was not cut at the most favorable season for this purpose.

The sinking of the mat was accomplished by distributing rock from a flatboat, which was gradually dropped down stream, broadside over the mat as it sunk. One cubic yard of broken rock was used to sink 1,150 square feet of mat. The rock used for sinking was a limestone of light density; it was towed in flatboats from Sioux City, where it was delivered on the river bank at $2 per cubic yard.

About 300 linear feet of mat, equivalent to three days' work, was usually sunk at one time. The distance between the boat and the sunken portion of the mat was never allowed to be less than 80 feet.

An average day's work for a gang of six expert workmen and nine ordinary laborers was 6,600 square feet of mat, in the construction of which 32 cords of brush were used.

As regards the permanency of revetments constructed on this system, I am of the opinion that if the work in the first instance is done in a thorough manner, and repairs are made when needed, their usefulness can be perpetuated indefinitely, as the material used will not deteriorate below extreme low-water stage, and the upper-bank protection can at any time be renewed and connected with the submerged portion.

The following is a detailed statement of the cost of the revetment per linear foot, built on the Nebraska shore above Covington:

STATEMENT.

		Cents.
Brush, 36.75 cubic feet, per linear foot, at $1,60 per cord		45.94
Broken rock, 1.6 cubic feet, per linear foot, at $2 per cubic yard		11.85
Cost of material per linear foot		57.79
Grubbing and cleaning	.0106	
Sloping bank	.1000	
Covering bank mat with earth	.0470	
Weaving mat	.2561	
Sinking mat	.0050	
Handling and transporting stone	.0371	
Measuring and inspecting material	.0168	
Repairs to boats and incidentals	.0360	
Superintendence	.0750	
Cost of labor per linear foot		58.36
Total cost per linear foot		$1 16.15

I am, major, very respectfully, your obedient servant,

SAMUEL H. YONGE,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

ADDENDA.

SAINT LOUIS, MO., *July* 23, 1880.

MAJOR: An inspection of the mat work constructed at Sioux City last fall showed that, though it had settled in places, it had nowhere pulled apart throughout its length of 2,000 feet.

About 1,000 linear feet of bank, of the 2,300 feet protected, washed out during the high water of June; this caving does not extend back at any point a greater distance than 20 feet.

I am informed that a great deal of the bank washing under the revetment was brought about by the action of the waves of the storm during the early part of June. I am led to believe that this caving consisted of a sloughing out of the fine sand composing the bank through and under the mat, after being saturated.

The channel continues to follow closely the Nebraska shore above Covington, and considerable caving has occurred below the lower end of the work during the April and June floods. This caving still continues, and is greatly increased by the high winds common to this locality.

Very respectfully, your obedient servant,

SAM'L H. YONGE,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 16.

IMPROVEMENT OF THE MISSOURI RIVER AT VERMILLION, DAKOTA.

As stated in my last report, the works projected at this place are designed to secure the bank of the river in the vicinity of Vermillion, and by certain rectifications in the channel, to secure a stable regimen.

Nearly all the small appropriation was expended at the date of my last report, and only some trifling repairs have been executed since then.

The destruction of the floating dikes by some unknown parties allowed the river to return to the channel in front of the town, and the revetment was violently attacked during the spring rise. Some damage was done, but it was quickly repaired, and the work has since stood well.

For details, I beg to refer to the accompanying report of Assistant S. H. Yonge, who had charge of the work.

The present appropriation will be expended in the prosecution of the plan adopted, more especially in endeavoring to avert the cut-off threatened above the town, and in renewing the attempt to divert the channel of the river to the east side of Vermillion Island.

I must again call attention to the fact that the appropriation is entirely incommensurate with the amount of work required and already estimated for.

Unless these appropriations are increased in amount, the ultimate cost will greatly exceed the amount of the first estimate, which is necessarily based on the supposition of continuous work being possible.

The work is situated in the collection district of New Orleans, and the nearest port of delivery is Omaha, Nebr.

The nearest fort is at Leavenworth, Kans.

Amount of revenue collected in Omaha, Nebr., during fiscal year ending June 30, 1880, was $3,605.21.

Money statement.

July 1, 1879, amount available	$1,256 35	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$11,256 35
July 1, 1880, amount expended during fiscal year		1,254 20
July 1, 1880, amount available		10,002 15
Amount (estimated) required for completion of existing project		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		60,000 00

REPORT OF MR. SAMUEL H. YONGE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *July* 7, 1880.

MAJOR: I herewith submit my report of operations conducted at Vermillion, Dak., during the fiscal year ending June 30, 1880.

After the destruction of the dike, situated 2 miles above Vermillion, the accretions which had accumulated around it rapidly disappeared. This allowed the river to return to the Western Chute and a further silting up of the Eastern Chute to occur. During the high-water in July I estimated that at least nine-tenths of the discharge of the river passed through the former chute. At the town the current impinged against the revetment at an angle of about 45°, and on the night of July 5, 1879, a section of matting 70 feet long, situated 400 feet below the head of the work, failed by tearing apart at the foot of the slope and by pulling out from the bank. This breach left the adjacent portions of the work exposed to the action of the currents, which began to undermine the bank.

The necessary repairs were immediately begun, and about 150 feet of the mat under which the bank had been undermined was tied up with ropes to trees and posts. A new layer of matting was begun 20 feet back on the bank and carried over and woven into the old mat.

During the remainder of the high-water the mat served as a very efficient protection. The accompanying cross-section sketch shows the shape of the bank where the break in the revetment occurred.

At the time the mat was constructed the top of the bank was from 3 to 8 feet above the surface of the water, and in consequence the slope did not have sufficient surface to give a very strong anchorage to the weaving; that part of the mat above water, therefore, was heavily weighted with stone. As this mat was constructed without the use of a boat, it was necessary to weave so that the outer edge would remain above

water, as it was carried out from the shore, to give the workmen a place to stand; for this reason the outer edge of the mat, when finished and sunk, raised above the bottom, as is shown in the sketch.

Owing to the steep angle which the mat assumed when sunk, a large quantity of the stone ballast which had been distributed over the mat rolled and accumulated in the pocket made by the rising of the outer edge.

It is probable that in swift currents this outer edge would have the see-saw motion peculiar to sawyers in the river, which, if continued for a few days, would have a tendency to cause the mat to ravel and pull apart.

By the method adopted subsequently at Sioux City, where a boat with inclined launchways was used, all parts of the mat as launched were equally submerged, and the work was carried down stream instead of across the current. This was found to give a far stronger construction than the old method, owing to the fact that the brush could be stuck into the mat at a lower angle, so that each piece of brush was woven in with a great number of other pieces. After the completion of the repairs, before referred to in this report, all operations at Vermillion were suspended.

During the low stage of water last spring the citizens of Vermillion made some very substantial repairs to the revetment, and I am of the opinion that the town is comparatively safe for several high-water seasons.

Heavy cutting has taken place on the down-stream side of the neck of land southeast of Vermillion, and a slight cutting on the upper side of the same neck during the last June flood. The danger of a cut-off through this neck is somewhat increased on account of the river bank on the upper side of the neck being only slightly elevated above ordinary high-water stage, and the surface of the ground across the neck inclining toward the down-stream bank. This danger would be lessened by the construction of a low levee, about 1 mile in length, along the river bank in North Bend.

I have the honor to be, very respectfully, your obedient servant,

SAMUEL H. YONGE,
Assistant Engineer.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

IMPROVEMENTS ON THE MISSOURI RIVER.

In my last report I made a brief statement of the principles upon which these improvements are based, and of the general conclusions to which I had then arrived. The practical experience of another year has fully confirmed these conclusions, while much valuable information has been collected.

Experiments have been carried out on the various plans and devices suggested, and have resulted in a notable saving in cost and increase of efficiency. It has been definitely settled that continuity in mattress work is essential, and that when this condition is fulfilled a very simple and to all appearances very slight protection is amply sufficient. Various forms of continuous mattresses were tried, most of them some variation of the woven type. They are all described in the reports of the assistants who used them.

Towards the close of the season experiments were being made on still simpler types, one of which is described in the report on Glasgow, and the work of this season will probably throw further light on this subject.

The greatest interest, however, attaches to the silt-catching devices, as by their use it is hoped to accomplish the training and contracting of the river, thereby deepening the channel and insuring a stable regimen.

These works are of limited application, except during high-water stages, so that our opportunities for work were limited.

The "Brownlow weeds," described in previous reports, were thoroughly tried, and although they are very efficient under favorable circumstances, yet there are palpable disadvantages attending their use, and they have been entirely discarded for more efficient constructions, which, under the head of curtains, will be found described at length in the reports on Nebraska City and Omaha.

Wate

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These curtains or screens were first constructed of brush and wire, the brush being vertical and the wires horizontal, with meshes 6 to 8 inches wide and 4 feet high. Later a netting of wire alone was tried, and gave such good results that it will be generally adopted this year. The advantage of this system is that the netting can be manufactured in quantities beforehand, so that no loss of time need be incurred in placing it in position. Moreover, the wire is cheaper than brush, and can be procured in any amounts needed at short notice. The only points to be settled are the best size of mesh, and the most economical system of manufacture and placing in position. These screens, when anchored in the river, at once begin to accumulate floating rootlets, grasses, and other similar materials, so that the mechanical resistance of the screen to the free flow of the current goes on increasing. A deposit begins at once, and in an incredibly short time a bar is formed on and below the screen, which may in very short time be brought to the surface of the water. Upon this bar the screen finally sinks, and then acts as a revetment for its preservation. In high-water a diamond-shaped mesh 16 inches wide by 24 inches high has been found much too small, the net being dragged to the bottom by the accumulation of *débris* before the desired shoaling had been accomplished. Heretofore these screens have been supported by buoys, the lower edge being of course anchored, but this method presents so many difficulties that attempts will be made hereafter to support them by piling, as piles, it is found, can be quickly and cheaply sunk by the use of a water jet.

The great amount of bank grading required is an important item in the cost of the work.

Experiments made at Omaha have shown that the hydraulic method offers great advantages both as regards expeditiousness and economy. Further statistics on this head will be obtained during the season.

The appropriations for the present year are small, and to insure the best results from their expenditure I believe that the greater portion of the money should go to works of channel rectification. By this means it is hoped that results of immediate and lasting benefit may be obtained, with the ultimate effect of a reduction in the amount of bank revetment needed. To do this work to best advantage high-water is needed, and as the season when this may be expected is now past, it is proposed to confine the present work to such operations only as may be absolutely indispensable, and to work of preparation.

When the ice goes out in the spring active operations will be commenced; and, as we will then have both the spring and summer floods to work on, it is hoped that results of importance will be obtained. In order to carry out this programme, it will be of the utmost importance that next year's appropriations may be made available at an early date, in order that the work may be continuously prosecuted.

The manner in which appropriations are made for these works is open to many and grave objections. While the aggregate sum alloted for the work is a large one, the special points designated for its expenditure are so numerous and so scattered that co-operation is impossible. Each work must, therefore, have a separate plant, and this, with the necessary supervision, is a very heavy tax on the individually small appropriations. Moreover, the appropriations are generally for some specific purpose, and work must be necessarily prosecuted accordingly, often at great expense, although the general results arrived at might be obtained at less cost and with greater general benefit by the adoption of a more comprehensive and less restricted plan.

The small annual appropriations are never great enough to enable any

piece of work to be completed; but only when completed can it be considered safe; hence, an undue proportion of each year's allotment must go to repairs of old work, and progress towards final completion is correspondingly slow.

In a river of such instability as the Missouri no work can stand by itself, but its relation to all neighboring works is intimate, and its dependence on them very great. Hence plans must be comprehensive, and work thorough, complete, and rapidly carried out, otherwise results will be very uncertain, and the cost unreasonably great. I believe that the only solution of the problem is the complete rectification of the river, which I hold to be feasible at a reasonable cost; but this work will require to be systematic, and carried on with no restrictions upon the judgment of the engineer as to time and place of expenditure. By making the work complete in sections of limited extent, I think that it could be carried on without imposing too heavy a burden upon the Treasury. I have now in preparation and hope soon to submit a report on this subject, with plan and estimates for the permanent improvement of the river as far as covered by our surveys; that is, from the mouth to Sioux City, Iowa, a distance of about 800 miles.

If the plan proposed proves acceptable, it is hoped that systematic and thorough work may soon supersede the present disjointed and desultory operations.

The assistants in local charge of works have displayed great zeal and energy in the prosecution of the duties assigned them, and also much ingenuity and fertility of resource in devising methods of work and special appliances for overcoming the difficulties which presented themselves.

The immediate supervision of the works on the Missouri was in charge of my assistant, Capt. Thomas H. Handbury, Corps of Engineers, U. S. A.

Q 17.

SURVEY OF THE MISSOURI RIVER FROM ITS MOUTH TO FORT BENTON, MONTANA, AND SURVEY OF THE MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY, IOWA.

At the date of my last report the party engaged in this work were 80 miles below Sioux City, Iowa, working down towards Weston, Mo., the initial point of the previous season's work. The field work was closed at this point September 6, 1879. Since then the field notes have been platted to a scale of 1 inch to 1,000 feet, making 27 sheets, each 40 by 120 inches.

During the present season it is proposed to connect these maps with those made in former years by the General Land Office, to run a line of check levels from the mouth to Sioux City, to fill in details of topography which have been found lacking, and finally to reduce the maps to a smaller scale and publish them.

The honorable Secretary of War having decided to allot $4,000 of this appropriation to the work at Sioux City as authorized in the act approved June 14, 1880, the operations here enumerated will exhaust the present appropriation.

In this act the designation of the appropriation is changed so as to fix the head of the survey at Sioux City, Iowa, but as it is extremely important that the survey of this great river should be continued to the

head of navigation, I submit again the estimates presented last year for this extension.

The work of the survey was carried on as during the previous season under the direction of Assistant D. W. Wellman.

Money statement.

July 1, 1879, amount available	$20,271 62	
Amount appropriated by act approved June 14, 1880	30,000 00	
		$50,271 62
July 1, 1880, amount expended during fiscal year		20,119 80
July 1, 1880, amount available		30,151 82
Amount (estimated) required for completion of existing project		100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 00

Q 18.

IMPROVEMENT OF GASCONADE RIVER, MISSOURI.

A survey was made last season of the Gasconade River between its mouth and Vienna, in Maries County, a distance of 78 miles. A report on this subject, with estimates, was submitted to you under date of February 11, 1880, and was published as Senate Ex. Doc. No. 99, Forty-sixth Cong., second session.

Congress, by act approved June 14, 1880, appropriated $5,000 for the removal of snags from the stream. It is proposed to expend this sum in the manner required by the law as soon as the river gets to a low stage, carrying the work as far as the available funds will allow.

This work is situated in the collection district of New Orleans, and the nearest port of delivery is Saint Louis, Mo. The nearest fort is at Leavenworth, Kans. Amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1880, was $1,176,009.57.

Money statement.

Amount appropriated by act approved June 14, 1880	$5,000 00
July 1, 1880, amount available	5,000 00
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	45,000 00

SURVEY OF GASCONADE RIVER, MISSOURI, FROM VIENNA, IN MARIES COUNTY, TO ITS MOUTH.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., February 11, 1880.

GENERAL: I beg leave to submit herewith a copy of a report of my assistant, Thomas T. Johnston, on the Gasconade River, Missouri, from Vienna, in Maries County, to its mouth. The survey of this stream was made under my directions by Assistant Johnston during the past season.

From this report it appears that for this portion of the Gasconade, some 78 miles in length, it is a small stream, the low-water discharge being only 450 cubic feet per second. The fall is heavy—108 feet in this distance—and the river is much obstructed by gravel bars, the

channels through which are tortuous and shallow. To thoroughly improve a stream of this character is a very costly operation, and before suitable plans could be prepared, more study and observation would be required than the hurried nature of our survey has enabled us to bestow upon the subject.

There is not much steamboat navigation on the river, but the rafting interest is important. Under these circumstances it has seemed best to confine our attention for the present to a project for deepening and straightening the low-water channels over the worst shoals by means of low, cheaply-constructed dikes, and for removing the snags which now obstruct the stream in many places. This partial improvement would no doubt be very beneficial to all the interests concerned, and during its progress opportunity would be afforded for a more thorough study of the problem.

Assistant Johnston's estimate for this work is $50,000, which could be profitably expended in one season. This estimate is approved by me.

Copies of the maps of the survey will be forwarded as soon as they can be traced.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. THOMAS T. JOHNSTON, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *January* 30, 1880.

MAJOR: I have the honor to submit the following, being my report of the survey of and the practicability of improving the Gasconade River from Indian Ford (near Vienna), in Maries County, Missouri, to the mouth of the river, and which was done in accordance with instructions received from you dated August 20, 1879, and September 9, 1879.

The survey of the river was commenced September 17, 1879, and completed October 29, 1879. A stadia line was run along the course of the river, from which all other points were located. The length of each change-line was measured from both ends. The directions of the lines were checked by reference to the true meridian about every 20 miles.

Topography back from the river bank was sketched as far as time and the amount of the allotment permitted. A line of levels was run to which the water surface was referred at about every 500 feet along the pools, and at shoals sufficient elevations were taken to determine the manner in which the water gets over them with reference to shape and slope. Cadenced soundings were taken in pools on sections averaging about 400 feet between centers; on shoals sufficient soundings were taken to determine its shape and the water depths, the sounder wading and pacing between soundings, thus getting them equidistant.

The country along the river was examined as far as possible. The accompanying maps show the results of the work, except that only enough soundings were platted to show the ruling depths on sections.

This part of the river crosses from side to side of a crooked valley between bluffs, which are from 1,000 feet to 1 mile (about) apart, the faces of which toward the valley show distinctly northeast and northwest trends; the general direction of the stream is northeasterly.

The bluffs are often precipitous, with rock ledges out-cropping; in a few instances they rise vertically from the water's edge, and in a few instances they were observed to rise abruptly from the level and high bottom lands. They are generally, however, footed by a talus which frequently obscures the original bluff face. The country in Maries County and Southern Osage County, near the river, is excessively broken, especially on the west side; the ridges are a mass of angular stones, varying in size from small gravel to pieces weighing several hundred pounds; the forests are thin and the underbrush scant; on the hillsides and in the bottoms the land is more or less fertile,

and much of it under cultivation; toward the Missouri River and east of the river the country is less jagged; it is thickly settled by Germans, who have placed most of the land (hill-top, side-hill, and bottom land) under cultivation, growing grapes, wheat, and corn in large quantities.

The bottom lands are quite level, being at the river banks generally about 20 feet above the low-water level of the river; in such places as the river is shifting about, or is influenced by the tributaries or by original valley topography, there are lower lands subject to frequent overflow. They are for the greater part very fertile, though in many places too sandy to be of much value. Where the river banks are being eroded, the material below the alluvial crust is shown to be a mixture of sand and gravel in varying proportions; tributaries cutting through the bottom lands show the same formation. No evidence of bed-rock was observed within at least 10 feet of the low-water level of the river. While the regular trend and the age of the bluff rocks indicate the pre-glacial existence of the valley, the limited area the river could ever have drained and the character of the valley formations indicate the flow of a large amount of water, such as could have been produced by the melting of glaciers.

The river is a series of pools and shoals, the low-water width of the channel varying from 60 to 500 feet, but being generally about 200 feet wide; as shown on the maps, the depth of the former varies from 20 feet to 3 or 4 feet, but for the most part showing a depth of 8 or 9 feet; the current in these is almost imperceptible at low-water. The maximum depths of water on the shoals vary from 2.5 to 1.3 feet, but for the most part being about 2 feet: the depth varies with the shape of the shoal to some extent. These shoals appear to be banks of gravel, acting as dams athwart the course of the stream; sand in the river bed is absent except near the mouth. The fall of the river from Indian Ford, as shown by the levels, is 107.895 feet, the Missouri River being low. The length of the river surveyed is 78¼ miles. The pools (as a rule) lie adjacent to the bluffs, while the shoals (as a rule) occur where the river crosses from bluff to bluff; they occur also (as a rule) very close to where the river commences a crossing, and rarely at the end of a crossing; frequently there are shoals between these points. There are a class of shoals which appear to be the consequence of some tributary, doubtless the latter bringing in material that the river is incapable of moving, thus forming a nucleus for a shoal. Two or three shoals along the bluffs are doubtless the consequence of some obstacle, as, for instance, a bed of snags. Undoubtedly snags have exerted a large influence over the formation of shoals. The river has an oscillation between high and low water of 22 feet, as given by a high-water mark at Pay Down. (Sheet 4.)

The slope of the country that the river drains is such that the water passes off rapidly, the river rising very rapidly and staying high but a short time. The prevalence of low-water is indicated by the growth of vegetation close to the low-water line. Persons living along the river were a unit in representing the river to have been unusually low during the past season. It was noticed that scarcely any water was brought in by the numerous small tributaries below Indian Ford.

IMPROVEMENT.

The quantity of water passing through the stream at extreme low-water does not vary much from 450 cubic feet per second. The shoals in the river, acting as dams, hold a depth of water behind them sufficient for all needs of navigation, while the water spreads over the dams in a more or less thin layer. The question turns on a method of passing these dams. Locks would answer the purpose, but are unnecessary and expensive. The present needs of navigation do not require a channel of more than 2.5 feet depth by about 30 feet bottom width and 60 feet or more surface width. The sectional area of the stream on the shoals shows that this can easily be had. It is believed that this can be had by using wing-dams and dikes of various construction. A considerable care must be used on placing them, particularly to make them sufficiently low. They should be no higher than sufficient to maintain the required channel. Some years ago Powell's dam (sheet 25) was built, which has caused changes in the river especially detrimental to navigation. It had, probably, a fall of 4 feet; as a consequence, the river below has a large fall and numerous shoals; exactly what its effect has been is difficult to decide, but an examination of the map will show it in a measure. Using a shoal in the capacity of a dam involves the consideration of its stability; the apparent relations between the positions of shoals and the features of the river indicate their permanency, though, doubtless, slow changes may exist; the material of which they consist is somewhat difficult of transportation, though the case of Powell's dam shows that it is moved in not small quantities; the way gravel has banked up below the dam shows what may be expected at any other dam; an artificial obstruction at Stake Shoal (sheet 29) indicates the same thing; likewise the shoal-forming capacity of snags. A low dam or immovable ridge on the crest of a bar shoal will prevent any undesirable changes, being coupled with needed protections at the river banks. Being assured of the permanency of the shoals, the works on any shoal may be considered.

Primarily, these should not damage the river elsewhere; to satisfy this condition the dams should be as low as possible, and not much alter the elevation of or fall over a shoal. It is partly on this account that it would be unadvisable to scrape a channel through the gravel shoals, thus reducing the level of the pool above, and maybe developing new shoals; moreover, this process would be equivalent to making wing-dams of loose gravel, which material (from personal observation) is easily moved when the regimen of the stream is molested. While satisfying this primary condition it must be considered how and where the channel over the shoal is to be. Its width will be governed by the fall over the shoal and the variation from the depth of channel proposed; this latter, to be accurate, will have to be determined by actual experiment; with the proposed channel-depth sufficient width (and more) can be had and the variation therefrom may have to be governed, but to what extent remains to be determined; however, it is believed that sufficient is known concerning the probable variation upon which to base estimates.

The location of the channel over the shoals involves the consideration of its ease of navigation; the cost of forming it; its chances of maintenance; the conditions above prescribed; and the consideration of erosion of banks. Experience has shown that boats can move up stream over the steepest shoals with no difficulty. Ease of navigation requires, then, only that the channel should be reasonably straight. The cost of forming the channel will depend on the nature of the shoal; the chances of maintenance depend on the same thing, together with the high-water action of the river. The discussion of these properties will not be undertaken here, but will, if desired, form the subject of a supplemental report.

The nature of the bottom-lands is such as to render them capable of easy erosion. Along the straighter pools, and where the concave side is a bluff, this action is absent on account of absence of current except at high-water and the protection of vegetation; at other pools, bending sharply, this action exists, though progressing slowly and only at the occasional high-waters. At shoals evidence of past erosion exists, and is at present progressing, and must be prevented from interfering with the improvements on any shoal.

PLAN.

It is proposed, in order to bring about an improvement, to use some device for concentrating and governing the flow of water through a channel, the location of which has been determined, in consideration of conditions before mentioned. These devices will have to be constructed, with few exceptions, where the water (at its lowest) is about 2.5 feet deep, or less, and in such a manner that the resistance of the device demanded will never be very great, which resistance is lessened as much as possible by the design of the devices; it is not believed that water-tight dams and dike will be demanded, at least only in rare instances. Having once fixed a section for the channel, the concentrating capacity and quality demanded will depend upon the shape of and fall over the shoal and the governing capacity on the same thing to a greater or less extent; the impossibility of calculating the intensity of these requirements makes actual experiment necessary to determine them. It is believed that the changes intended on any shoal will take place so rapidly that the effect of the works can be observed approximately at once, and thus govern their extent. The estimates below are based upon the effect of the works anticipated, and it is believed they will not vary much from what will be needed. Where a wing-dam or dike is needed over 2 feet high, brush and stone will be used (depending, of course, on the resistance demanded); where a less height is needed, poles and planks driven into the gravel in single or double rows (depending on the case), somewhat after the nature of sheet piles, either alone or backed by stone, or gravel will answer for dams and dikes. These will be driven 2 or 3 feet into the gravel, or until they take a firm hold and are out of the limit of scour; when used to deflect the current, poles alone will answer, driven several inches apart; none of these works are intended to reach above low-water; in many cases even this height will be unnecessary (besides the previously mentioned conditions, the desirability of maintaining the point of maximum scour at or near low-water will govern the height of the works). Similar works will be used to prevent the bars from giving openings for other channels and for governing undesirable scour in the channel. The parts of this class of work that may be subject to hard knocks, as from rafts or boats, will be of the same construction, but stronger than elsewhere. It is believed that the spaces behind the works will fill up with sand and gravel, and that these sediment banks and the works will afford mutual protection. The greatest danger to this plan is the possibility, though remote, of the channel filling up at high-water in a manner to prevent it being opened again at low-water. This objection is common to all wing-dam and dike systems, and can be obviated only by work in the nature of maintenance and repairs.

The survey of the river develops 76 places needing improvement, as shown on the maps and in the following table. The estimates are based upon the condition of the river when surveyed, and will vary with any variation in the shoal prior to improvement. No changes are anticipated which will much alter the amounts. Dike and

dam work has been placed at an average cost of 25 cents per running foot, as determined by averaging the amount of work on a number of shoals. These estimates refer to the actual cost of construction. Ten per cent. has been added on account of possible error in estimates, and the same amount on account of such scraping and governing of the channel as may be needed to develop the intended effect of the work.

List of shoals and estimates for improvement.

Number.	Distance from mouth of river in miles.	Cost.	Number.	Distance from mouth of river in miles.	Cost.	Number.	Distance from mouth of river in miles.	Cost.
1	78.00	$375	28	55.75	$250	55	25.25	$100
2	76.25	1,250	29	54.75	500	56	24.75	100
3	74.50	1,000	30	54.25	50	57	24.25	150
4	73.75	150	31	53.25	250	58	22.25	600
5	73.25	50	32	52.25	200	59	21.75	150
6	72.50	500	33	50.50	600	60	21.25	75
7	71.50	150	34	49.75	75	61	20.50	75
8	71.25	150	35	48.25	200	62	20.00	400
9	70.25	375	36	47.50	200	63	18.25	300
10	69.00	1,250	37	46.50	500	64	17.25	700
11	68.25	150	38	45.75	150	65	16.25	200
12	68.00	375	39	45.25	700	66	14.00	75
13	67.25	375	40	44.50	150	67	13.12	150
14	66.75	375	41	44.25	150	68	12.25	300
15	66.00	200	42	43.25	300	69	11.75	150
16	65.25	600	43	42.25	500	70	10.75	150
17	64.37	250	44	41.50	150	71	10.25	150
18	63.25	1,000	45	40.75	50	72	8.25	250
19	62.25	200	46	40.25	700	73	7.75	150
20	60.75	125	47	39.00	200	74	7.00	500
21	60.25	50	48	37.75	50	75	6.25	300
22	59.50	150	49	36.75	150	76	3.25	250
23	58.75	250	50	34.75	150			
24	58.00	700	51	29.75	1,500	Amount		24,200
25	57.25	200	52	28.00	250	20 % +		5,800
26	56.75	250	53	27.50	250			
27	56.50	50	54	26.25	150	Total		30,000

See profile of river for fall and length of shoals.

SNAGS.

There are localities along the river favorable for the location of snags; and at those places they are sometimes so thick that a boat or raft cannot pass without coming in contact with them. These localities are at such places as the banks are being eroded, either along pools or at shoals; also at the heads of islands. They occur also, as a rule, in groups, an isolated one being rare. There are long stretches of the river where none will be found. They seldom locate in the channel on shoals, except where erosion of banks exists. There are, then, a number of localities, more or less full of snags, enumerated below. They are easily accessible from the shores, and can be removed by apparatus located thereon, and by blasting.

Loggybend.
One mile above Pay Down.
Devil's Race Shoals.
Buck Elk Shoal.
Scott Island.
Ramsey Shoal.
Rollins' Ferry Shoal.
Above Owen's Mill.
Below Pointer's Creek.
Head of Deer Slough.
Massey Island.
Bumper's Shoal and above.
Prior's Bend.
Lotta Lewis Shoal.
Deppy Bend.
Powel's Dam.
Below Round Island.

ESTIMATES FOR REMOVING SNAGS.

Cost of outfit (boats, apparatus, &c.)	$1,000
Work of one season—employés	5,000
Superintendence	1,000
Repairs of apparatus and material	1,000
Margin for variation from estimates	1,000
Amount for one season's work	9,000
One season's work will probably be required to complete this work, making the total cost	9,000

RAFT NAVIGATION.

Rafting is, at present, the only traffic done on the river, though several boats have been up the stream. Lumber and railroad ties are rafted in various quantities year by year. It is estimated that 80,000 ties were rafted in the year 1879. Not much lumber came down, due, probably, to the very low-water and the small demand for that article. At low-water this business is difficult and expensive, rafts frequently being broken up and destroyed. Undoubtedly, this business would be a large one in this river if the rafts could be taken out at a reasonable cost. The present greatest width of rafts is 32 feet; in order to pass some shoals, it is necessary to split them in half longitudinally. A channel-way that allows this width of raft to be increased cannot be considered practicable in this river; it remains, then, to make it deep enough to allow the thickness of rafts to be increased; the present thickness under water scarcely exceeds 8 inches. The rafts are always long—about 200 feet—and their trouble lies in getting through crooked channels. Some benefit would accrue from rectification of the channel in various places; the cost of auxiliary works necessary to maintain such a channel would make the total cost, approximately, very close to the cost of the works for boat navigation. It is believed best, on this account and the importance of the raft trade, to fix a quality of raft navigation at such as will be a consequence of the boat channel proposed.

VALUE OF THE PROPOSED IMPROVEMENT.

The benefit to be derived from the improvement of this river would be to afford cheap and convenient transportation for the products of a large portion of Maries, Osage, and Gasconade counties in Missouri, and to make further development of the country profitable; wheat and corn are grown in large quantities. The mineral resources of this region are almost wholly undeveloped; iron ore is plentiful. An outlet would be afforded for much oak and pine lumber.

No reliable statistics of the products of this region exist.

SUMMATION.

Cost of improvement (actual construction)	$30,000
Superintendence, surveys, office expenses	10,000
One season's work removing snags	9,000
Tools, boats, and material	1,000
Total	50,000

It is recommended that this work be done in one year, as being economical, and that the 50,000 be expended during the next fiscal year.

Attention is respectfully called to the condition of the bridge of the Missouri Pacific Railroad, near the mouth of the river (sheet 31); it has no draw-span, although the piers are constructed for one; at low-water, in both the Missouri River and the Gasconade, the lower chord of this bridge was 32.83 feet above the water surface. The channel-way either side of the pivot-pier is obstructed by the remains of a former trestle bridge.

Attention is also called to the existence and operation of a grist-mill, as shown on sheet 20 of the map.

Respectfully submitting the above to your consideration, I am,

Very respectfully, your obedient servant,

THOS. T. JOHNSTON,
Assistant Engineer.

Maj. CHAS. R. SUTER,
Corps of Engineers, U. S. A.

Q 19.

IMPROVEMENT OF ARKANSAS RIVER BETWEEN FORT SMITH, ARKANSAS, AND WICHITA, KANSAS.

No snag-boat of sufficient light draught was available for work in this portion of Arkansas River till the end of the winter, when the new snag-boat Chauncey B. Reese was assigned to that field. Owing to the low stage of water, the lateness of the season, and the great number of snags that had to be removed to admit the passage of the boat, but little

could be accomplished and the boat was withdrawn. Operations will be resumed at the first favorable opportunity and carried as high as the railroad bridge, 3 miles above Grand River and 97 miles from Fort Smith. This bridge has no draw and is impassable for steamers of any size.

During the coming season it is proposed to set a party at work at the upper end of the district. They will work at low-water, either from flat-boats or the banks of the stream, and will remove snags and rocks from the channel, and perhaps build a few dams on the worst shoals. These operations will be carried on as far as the funds available will allow, and will, it is thought, benefit at least flat-boat navigation, which, with the impassable bridges below, is all that the stream is now capable of. During the past season the dike built at Fort Smith was found to have settled slightly. It was raised to the proper level, and at last accounts was in good condition and had accomplished perfectly the object intended, that of giving a good and accessible harbor to the town of Fort Smith.

In order to carry on such work as is at once needed an appropriation of $40,000 will be necessary, and I beg leave to renew my recommendation of an appropriation of $16,300 for such a survey as is needed to develop a plan of permanent improvement.

The work is situated in the collection district of New Orleans. The nearest port of delivery is Memphis, Tenn., and the nearest fort is Fort Smith, Ark.

The amount of revenue collected at Memphis, Tenn., during fiscal year ending June 30, 1880, was $21,051.52.

Money statement.

July 1, 1879, amount available	$20,000 00	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$35,000 00
July 1, 1880, amount expended during fiscal year		18,591 75
July 1, 1880, amount available		16,408 25
Amount that can be profitably expended in fiscal year ending June 30, 1882.		56,300 00

Q 20.

IMPROVEMENT OF ARKANSAS RIVER AT PINE BLUFF, ARKANSAS.

A general plan for the improvement of Arkansas River at this locality was submitted to you under date of January 23, 1880, printed as Senate Ex. Doc. No. 67, Forty-sixth Cong., second session.

Congress by act approved June 14, 1880, having appropriated $25,000 for this work, it will be taken in hand at once and pushed as far as the available funds will allow.

This work is situated in the collection district of New Orleans. The nearest port of delivery is Memphis, Tenn., and the nearest fort is Fort Smith, Ark.

The amount of revenue collected at Memphis, Tenn., during fiscal year ending June 30, 1880, was $21,051.52.

Money statement.

Amount appropriated by act approved June 14, 1880	$25,000 00
July 1, 1880, amount available	25,000 00
Amount (estimated) required for completion of existing project	75,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	75,000 00

SURVEY OF ARKANSAS RIVER, IN THE VICINITY OF PINE BLUFF, ARKANSAS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 23, 1880.

GENERAL: I beg leave to transmit herewith a copy of the map of a survey of Arkansas River, in the vicinity of Pine Bluff, Ark., made under my direction during the past summer, together with a report from my assistant, Capt. Thomas H. Handbury, Corps of Engineers, U. S. A., submitting a plan and estimates of cost for the improvement of the river at this locality. From these documents it will be seen that the objects proposed are three in number. They are:

1st. To protect the river bank immediately in front of the town from further erosion.

2d. To rectify the course of the river in the bend above the town, in order to remove a bar now existing there, which is an impediment to navigation, and also, by diminishing the curvature of the bend, to lessen the tendency to excessive scour in front of Pine Bluff.

3d. To prevent the formation of a cut-off now threatened across the neck of the peninsula opposite Pine Bluff, which, if allowed to take place, will leave that town nearly 4 miles from the river, and will have injurious effects on the river above and below. The whole improvement will extend over about 13 miles of river.

To accomplish the objects proposed, the plan contemplates the use of methods and appliances which have given excellent results on the works of improvement carried on under my direction on the Missouri River, and which I have no reason to doubt will give equally good results here.

The revetment of 36,000 linear feet of bank is deemed necessary, as also the construction of 2,000 feet of floating brush dike.

The plan proposed by Captain Handbury expresses my own views on this subject, and the estimates submitted are also approved by me. They are as follows:

For revetting 36,000 feet of bank, at $2.50 per foot	$90,000
For constructing 2,000 feet of floating brush dike, at $1 per foot	2,000
For superintendence and contingencies	8,000
Total	100,000

Which can be profitably expended in one season. In order that the work may be accomplished with the greatest economy and dispatch, it is very desirable that the whole sum estimated as necessary should be appropriated at once.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF CAPTAIN THOMAS H. HANDBURY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., January 17, 1880.

MAJOR: In obedience to your verbal instructions received a few days since, I have the honor to submit the following plan and report thereon for improving the navigation of the Arkansas River, in the vicinity of Pine Bluff, Ark.:

The town of Pine Bluff is situated upon the right bank of the Arkansas River, about 172 miles by water from its mouth.

It is the center of a large agricultural trade, and the point from which the cotton product of this section is shipped to the markets.

The Arkansas River, in its lower reaches, flows through soft alluvial bottom land, which it has probably transported from its upper regions. It belongs essentially to the sediment-bearing class of rivers, and, like all of these, is constantly changing its bed and channels.

As we study the effect of these changes upon navigation, and upon the interests along the banks, we observe that they are sometimes beneficial, but more often detrimental. In the location that we are now considering the changes that have been going on in recent years have been of such a nature as to interfere seriously with the prosperity of various interests, and they are still very threatening in their character.

The town of Pine Bluff has suffered much from the constant erosion by the river of the land upon which it is built. The upper stratum of this land, down to perhaps the level of low-water, is of a tough, tenacious nature, which withstands well the action of the current, but beneath this there is a stratum of quicksand which is readily washed away whenever the force of the current is brought to bear against it. Being left without support, the upper mass tumbles into the river and in a short time is carried away, leaving the quicksand stratum again exposed and the same process to be repeated.

In consequence of this action much valuable property has already disappeared and still more is in danger.

The water just along the town front, and for some distance below, is deep, affording at all stages a good navigable channel. But, in consequence of a very short turn that the river is obliged to make just above the town, the velocity of the high-water is checked and large deposits are formed. During the low-water and medium stages there is not sufficient time for these deposits to be removed by the natural forces at work; consequently they materially interfere with the general navigation of the river at this point.

These are evils that are present, and in the interests of the communities above Pine Bluff, as well as at the town itself, should be remedied without delay. Aside from these there is one that is prospective and threatening great danger to all interests concerned at no very distant future day.

This, however, if judicious steps be now taken, can be avoided.

By a glance at the accompanying map it will be seen that Pine Bluff is situated opposite the apex of a peninsula-like piece of land.

The narrow portion of this is being rapidly eroded by the action of the water both upon its upper and lower sides. A small amount of funds judiciously expended would stop these erosions. They should be taken in hand at the earliest possible moment, for if allowed to go on, a cut-off will take place which will not only greatly disturb the regimen of the river and impair its navigation, but will leave Pine Bluff and all its river interest 4 miles from its steamboat landing with a high-water slough to cross before it is reached.

The river would be shortened by this cut-off about 10¼ miles, and its slope changed from $\frac{3}{10}$ of a foot per mile to about 4 feet per mile.

In its general characteristics the Lower Arkansas River bears a strong resemblance to the Missouri. Like it, it flows through a loose sandy or alluvial bed, formed of the materials which it has brought down from its higher reaches. Like it, it is constantly eroding its banks and shifting its channels, and like it, too, it is constantly carrying down large quantities of sediment, more or less of which is dropped wherever there is a check in the velocity of its current. It is reasonable to conclude that the same principles that have been successfully applied to the improvement of the navigation and the amelioration of the evils arising from the erosions caused by the one would be equally applicable to the other, and I see no reason for making any material difference in the practical application of these principles.

For stopping the erosions I would recommend that the banks be revetted where necessary with a thin and flexible layer of willows or brush, made into a continuous mat or blanket; this to extend down the bank, which I would first grade to a slope of not greater than one on one and one-half, and out along the bottom of the river sufficiently far to give protection against any scour that might affect the foot of the bank. On account of the tough and unyielding nature of the strata above low-water in the localities where revetment will be necessary in this case, I do not anticipate that a high-water revetment will be necessary. The revetment need not extend much above the ordinary low-water line.

For cases where it may be desirable to change the course of the river somewhat, I would recommend some form of structure that would check the velocity of the current and cause a deposit to take place, which would deflect the water in the desired direction. Either the "stiff-brush" dike, the floating dike made with an assemblage of "weeds," the willow or the wire curtain, might be used for this as the occasion might demand and expediency suggest.

From our successful experience upon the Missouri River, and the well-known sedi-

ment-bearing character of the Arkansas, I have no hesitancy in recommending these methods.

I do not deem it necessary at this time to go into a detailed estimate of the cost of works of this character, or to explain with much minuteness the probable effect that they will produce.

It will suffice to say that all our experience with them upon the Missouri River has been eminently satisfactory both as regards expense and results attained.

For the revetment it is safe to estimate that $2.50 per running foot of shore-line will be sufficient, and for the floating brush dike $1 per running foot.

To solve the problem now before us, I do not think that at present we need go higher up the river to commence our work than about 4,000 feet above Cady Place, although at some future time it may be found advisable to carry the work into the bend above, or perhaps higher. This point I have marked A upon the accompanying map. From here I would recommend a continuous revetment downstream for about 18,000 feet to the point marked C. This would prevent the further erosion of the upper side of the narrow neck where the cut-off is threatened, and hold the point of land opposite Pine Bluff. Between B and C I would interpose, perhaps, three or four brush dikes, with a view to deflecting the current to the opposite shore and causing it to erode the sand-bar that is there found and increase the radius of curvature of the bend in front of the town. The position and length of these dikes are matters to be determined by the conditions existing at the time their construction can be commenced. It is not probable that they will be required to be more than 500 feet in length.

In the bend, as it will be formed after the dikes have produced their effect, about 6,000 feet of the bank will probably need revetting; the bank in the immediate front of the town, from Brump's Bayou down to White's Bayou, a distance of about 6,000 feet, is now very much in need of protection, and should be revetted at once. Between this and the lower side of the narrow neck where the cut-off is threatened there is no point that needs especial attention at present.

From D to E, a distance of about 6,000 feet, it will be necessary to revet the bank. This I should put as the limit of improvement in this direction at present. At some future day, when the general problem of improving the river throughout its whole extent comes up for solution, the propriety of extending these works in either direction will doubtless receive consideration.

The map which accompanies this report is a reduced copy of the one made under your directions in 1879, by your assistant, J. H. Curtis. It gives a clear idea of the condition of the river at that time, when the water was at a medium low stage. Changes have undoubtedly taken place since, and will continue to do so until the contemplated works of improvement can arrest them. These may necessitate some modification in the proposed plan, which, under the circumstances of the case, can be done to the best advantage when the work is about to be commenced and as it advances.

The following is the amount that I estimate will be required for carrying out the plan of improvement above proposed; and I would respectfully suggest the propriety of recommending that the whole amount of the estimate be appropriated at once; otherwise the money and time lost in protecting the partially completed works from destruction by the river during the intervals when funds are not available will make the ultimate expense far exceed the present estimate:

For revetting 36,000 feet of bank, at $2.50 per foot	$90,000
For constructing 2,000 feet of brush dike, at $1 per foot	2,000
For superintendence and contingencies	8,000
Total	100,000

Respectfully submitted.

THOS. H. HANDBURY,
Captain, Corps of Engineers.

Maj. CHARLES R. SUTER,
Corps of Engineers, U. S. A.

APPENDIX R.

IMPROVEMENT OF MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE—IMPROVEMENT OF YELLOWSTONE RIVER.

REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., August 4, 1880.

GENERAL: I have the honor to forward herewith my annual reports for the fiscal year ending June 30, 1880, upon the works of river improvements in my charge.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant, Corps of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

R 1.

IMPROVEMENT OF THE MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

The work of improving the Missouri River above mouth of Yellowstone may now be considered as divided into two distinct branches, viz: That to be done upon the river above the Great Falls, and the continuance of that on the river below Benton.

THE WORK BELOW BENTON.

On the 31st of July, 1879, a force consisting of two assistant engineers, two recorders, three overseers, one suboverseer, and fifty-six men left Saint Paul for the scene of operations. It was the intention to start work with one party at Kipp's Rapids, to set another party at work at Castle Bluff Rapids, and to employ a third in dam-building at Grand Island.

The boat which carried the parties left Bismarck August 2, but unfortunately, having been heavily loaded and the river having suddenly fallen, the journey was a very slow and tedious one. Grand Island was reached August 18, and one overseer and twenty-one men were put off there. On the morning of August 22 the boat ran hard aground at Bird's Rapids, only 25 miles above Grand Island. It was found necessary to lighten the boat, and as there were serious doubts as to the possibility of reaching Kipp's Rapids, the party destined for the latter place, con-

sisting of Assistant Engineer Wood, one recorder, one overseer, and thirteen men remained at Bird's Rapids.

The boat was disabled below Dauphin's, and did not arrive at those rapids until August 26. The necessary preparations in the way of caulking and repairing the boats were made and work commenced August 29.

The dam at Dauphin's had been somewhat injured by the ice. The necessary repairs were made and the party moved to Castle Bluff Rapids, 3½ miles below, on September 4. To this dam 168 cubic yards of stone were added and 140 cubic yards, which had been rolled below the dam by ice, were replaced.

At the foot of a gravel bar, ½ mile above Castle Bluff, 71 cubic yards of rock were taken out. The work required thirty-one blasts.

At Castle Bluff Rapids a channel 100 feet in width was cleared. With the aid of 149 blasts 388 cubic yards of rock were taken out. The work at this place was completed October 6, and the party moved to the lower reef at Chimney Bend, 2¼ miles below. At this place there was 1½ miles of "bad river." There are essentially two distinct reefs ½ mile apart. The lower reef was one of the worst places on the river.

The camp was moved to the upper reef October 18, and there remained until the close of the season. At the two reefs 318 cubic yards of rock were removed, requiring 203 blasts.

The party at Bird's Rapids was occupied in building the requisite boats until September 10, on which date the actual work was commenced. At the head of these rapids is a gravel bar with only 2½ feet for a length of 200 feet. It will be necessary hereafter to build a dam out from the right bank. Below this bar for a distance of 2,300 feet there is a depth of from 3½ to 5½ feet. A 100-foot channel was cleared through this portion. At the foot of the rapids the water is from 4 to 12 feet deep. The obstructions here were 3 points of a ledge, over which there was from 8 inches to 3 feet of water. The first point was 8 feet by 14 feet, surrounded by water 8 feet deep. In it five holes, 5 feet below water surface, were drilled and the blasts procured the required depth of water over it. The second point was 15 feet by 30 feet, with a surrounding depth of water of from 4 to 9 feet. In it seventeen holes, with a total of 52 feet depth, were drilled. The bottom of the holes were 4½ feet below water surface. The blasts broke it up but did not clear it away and the grabs had to be used. The third point was 12 feet by 28 feet, with a surrounding depth of water of from 5 to 9 feet. Twenty-four pounds of No. 1 dynamite, exploded in seventeen holes 5 feet below water surface, cleared away the rock. These three rocks lay within an area of 70 feet square. Their removal has secured a good channel at what was one of the most dangerous places on the river. By these blasts 63 cubic yards of rock projecting above the 3-foot level were blown down. The grabs removed 114 cubic yards. The work was completed at this place and operations commenced at Cabin Rapids, 1½ mile above, October 8. At the latter place there were only a few large bowlders, 24 cubic yards in all, lying in from 3½ to 5½ feet of water. They were removed and work commenced at Magpie Rapids October 14. The water at the latter place is from 5 to 7 feet deep, and it was necessary to remove only the larger rocks. This was done over a channel length of 3,000 feet. The number of cubic yards taken out was 131½.

On October 23 the party moved to Lone Pine Rapids and removed 23 cubic yards of rocks.

On October 25 the party moved to the foot of Chimney Bend and worked for 4 days on the lower reef.

At Grand Island the ice gorged on the dam built in 1878 and carried

away 110 feet of the island end. To repair the damage, 431 cubic yards of stone and 806 fascines were required.

A wing-dam 950 feet long, containing 378 cubic yards of stone, was built from the point above Grand Island.

The chute at Hammond's Island was closed by dam 245 feet long, containing 262 cubic yards of stone and 580 fascines.

A spur-dam 350 feet long, containing 218 cubic yards of stone and 475 fascines, was built from the foot of Grand Island to a gravel bar below. This work was finished October 15, and the party moved to Cow Island October 16, where it remained until October 24 repairing and strengthening the dams.

Two hundred and twenty-eight cubic yards of stone were placed on the upper and middle dams. The party moved to Chimney Bend on October 24.

The total amount of work done was as follows:

Number cubic yards rocks taken out	1,064¼
Number of blasts	493

The above does not include the 63 cubic yards blown down at Birds Rapids, and there were other blasts of the results of which no account could be kept in terms of cubic yards.

Number cubic yards stone placed in dams	1,825
Number fascines placed in dams	1,861

A survey of the river from Dauphin's to Bird's Rapids was made during the season of very low-water.

The work has been plotted. A map showing the improved portions of the river has been photolithographed.

The work of the coming season will consist in building a wing-dam at the bar 2 miles below Dauphin's, in closing the right chute at Snake Point, 3 miles above Cow Island, and in clearing the channel at Island Rapids, Bear's Rapids, and Gallatin Rapids. Assistant Engineer Stevens will have charge of this portion of the work.

In March last I submitted to the Chief of Engineers a special report upon the improvement of the river above the Great Falls. Last September I made a cursory examination of the river by descending it in a mackinac, but I was subsequently authorized to have a detailed survey made; and the accurate information thus obtained has led me to modify somewhat my opinions.

The party engaged upon the survey consisted of three assistant engineers and twelve men. The work was commenced at Stubbs Ferry, 12 miles from Helena, April 9; and completed to the mouth of Sun River May 28.

The men were discharged in Helena May 31. Messrs. Stevens and Wood, assistant engineers, arrived in Saint Paul June 13.

Owing to the fact that preparations and estimates for the coming season's work had to be made the maps of the river above the falls are not complete. I, however, forward herewith tracing of Bear's Teeth Rapids, Bear's Teeth Shoal, and Lone Pine or Half-Breed Rapids.

The amount of work accomplished was as follows:

Number of miles of river	131.3
Number of miles developed shore line	355.75
Number of lines sounded	3,395
Number of soundings taken	43,146

There were 37¼ workings days, giving an average daily progress of 3.52 miles.

The river bed is of gravel, the banks are stable, and the shoals, as a rule, are not bad or of frequent occurrence. The greatest hinderance to

its easy navigation is the rapidity of the current on the rapids. The swiftest current observed was 5 miles an hour.

The slope of the river from Stubbs Ferry to the foot of Bear's Teeth Shoal is 4.05 feet per mile; from the foot of Bear's Teeth Shoal to Gibson's Ferry it is 3.54 feet per mile. The most excessive slopes are at Bear's Teeth Rapids, Bear's Teeth Shoal, and Lone Pine Rapids, being, respectively, for ¼ mile, 20.4 feet per mile; for ¾ mile, 12.36 feet per mile; and for ½ mile, 18.35 feet per mile. I use the name Lone Pine Rapids instead of Half-Breed Rapids, for the reason that the former is the old Lewis and Clark name, and I can see no good reason why Roberts should have changed it.

Accepting the water of April 21, the lowest water observed, as low-water, there are but three places of a less depth than 2½ feet. Of these the most important is Bear's Teeth Shoal. Here, as will be seen by the tracing, the river is divided by two islands. The bottom is of gravel and of stones from 4 to 12 inches in diameter. The width of the main channel is 500 feet. The soundings show a channel depth near the head of the lower island of 2 feet. From about the middle point of the island, towards the foot, nature has contracted the stream and a good depth is found.

Bear's Teeth Rapids has a crooked 3-foot channel choked with rocks.

Lone Pine Rapids is a very dangerous place. An island divides the river. At the foot of this island 2 reefs make from the opposite banks, overlapping in the channel.

From Gibson's Ferry to Sun River, the Missouri, for the purpose of such navigation as can be accommodated by the river above, is all that can be desired. The slope, nearly uniform, is only 0.56 foot per mile; the current is sluggish, and the channel is free from snags, rocks, and sand bars.

At a point $\frac{8}{10}$ mile below Sun River, where the survey terminated, a series of falls commence, and this point is the foot of navigation on the Missouri River above the Great Falls.

Assistant Engineer Wood, with one overseer and one laborer, will leave Saint Paul for Helena on the 20th instant. A party will be organized in Helena, where, also, the lumber and subsistence supplies will be purchased. Most of the material will be taken from the depot at Chimney Bend.

Work will be commenced at Bear's Teeth Shoal, where the party will construct the necessary dams. That work completed, the rocks will be removed from Bear's Teeth Rapids, and at the close of operations there the party will proceed to Lone Pine Rapids. It is expected that this work will be carried on until December next.

In referring to the assistant engineers it is only necessary to state that Mr. H. E. Stevens brought his accustomed energy and ability to bear upon the work both in field and office, and that credit is due Mr. W. H. Wood for his close attention to and good execution of the work assigned to him.

Money statement.

July 1, 1879, amount available	$52,279 62	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$77,279 62
July 1, 1880, amount expended during fiscal year	30,389 15	
July 1, 1880, outstanding liabilities	338 59	
		30,727 74
July 1, 1880, amount available		46,551 88
Amount that can be profitably expended in fiscal year ending June 30, 1882.		150,000 00

R 2.

IMPROVEMENT OF YELLOWSTONE RIVER, MONTANA AND DAKOTA.

Under date of December 11, 1879, I forwarded a special report upon the improvement of the Yellowstone River. That report contained nearly all the information to be submitted.

The office work consisted in the plotting of the season's work and in making the necessary estimates for the present season.

Assistant Engineer Towar, with one party, will be sent to Buffalo Rapids to complete the improvements at that point.

Assistant Engineer Durage will be sent with another party to Baker's Rapids to remove the obstructions, and thence to Wolf Rapids to clear the channel at that point.

My thanks are due to Mr. F. M. Towar, assistant engineer, for the excellent work done by him during the season.

Money statement.

July 1, 1879, amount available	$25,000 00	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$40,000 00
July 1, 1880, amount expended during fiscal year	10,403 87	
July 1, 1880, outstanding liabilities	173 00	
		10,576 87
July 1, 1880, amount available		29,423 13
Amount that can be profitably expended in fiscal year ending June 30, 1882.		100,000 00

R 3.

SURVEY OF THE YELLOWSTONE RIVER.

Under date of July 1, 1879, I submitted a report upon the survey of the Yellowstone River. In that report the nature of the river and its value as a line of communication and transportation were discussed. There is but little more to report upon these points. The settlements have increased in number, and the shipments of private freight have increased in value and amount.

As there was no provision made for a continuance of the survey during the present fiscal year, a report of the work done during the two seasons of 1878 and 1879 is submitted.

The sum of $15,000 of the amount appropriated for examinations, surveys, and contingencies of rivers and harbors by the act of June 18, 1878, was made available for the survey. Two parties, each consisting of two transit men, one leveler, one recorder, and fourteen men, were placed in the field September 6, 1878, and remained at work until October 27. One party commenced work at Fort Keogh, and the other near the mouth of Powder River. The total number of days of surveying work was 33, and the work accomplished in that time was—

Miles of river	145¼
Miles of developed shore line	527
Number of soundings	59,731
Number of sounding lines	3,056
Number of sets of azimuth observations	24
Number of sets of gaugings	3

On November 5 all of the men, with the exception of three assistant engineers, were discharged. The latter were retained until the close of

the fiscal year to plot the season's work. A map of the river in 42 sheets, on a scale of $\frac{1}{9600}$, with index sheet, was forwarded to the Chief of Engineers and photolithographed. A map in 16 sheets on a scale of $\frac{1}{4800}$ was made for use in this office.

The sum of $4,000 of the amount appropriated by the act of March 3, 1879, was made available for continuing the survey.

On July 31, 1879, a party, consisting of Assistant Engineer Lightner, one leveler, and nine men, left Saint Paul for Terry's Landing, where it arrived August 11. The field work was commenced August 15, and continued until October 15 with little interruption, the weather having proved favorable to the progress of the work.

There were 51 actual working days, in which time the following work was accomplished:

Miles of river	111.2
Miles of developed shore line	383
Number of sounding lines	1,656
Number of soundings	30,331
Number of sets of azimuth observations	14
Number of sets of gaugings	3

The azimuth was carried from station to station by both chain and stadia lines. The stadia work, which was plotted in the field, was closely checked by the chain line. The level line was run close to the edge of the water, and the level of the water surface taken at points about 700 feet apart.

The stretch of river surveyed during 1879 extends from Junction City (a small village 1 mile above Terry's Landing) to Fort Keogh, and the connection with the previous season's work was made at this latter point.

The men, with the exception of Assistant Engineer Lightner, were discharged in Saint Paul October 26. The latter was retained until April 15, when the appropriation having become exhausted he was discharged.

The office work during the year consisted of the necessary computations and plotting. A map of the river in 31 sheets on a scale of $\frac{1}{9600}$, with index sheet, is forwarded herewith. A map in 10 sheets on a scale of $\frac{1}{4800}$ for use in this office is in progress, and is nearly completed.

During the two seasons the following work has been accomplished:

Miles of river surveyed	256.45
Miles of developed shore line	910
Number of sounding lines	4,712
Number of soundings	90,062
Number of sets of azimuth observations	38
Number of sets of gaugings	6
Daily progress of miles of river	3.05

The following are the results of the gauging:

Discharge, locality, and date.	Cubic feet per second.	Stage of water in feet above low-water level of 1878.
Mouth of Big Horn, August, 1879 (Big Horn, 5,865; Yellowstone, 7,471)	13,336	1.70
At Fort Keogh, September, 1878	14,462	1.87
At Fort Keogh, October, 1879	6,505	0.15
At Wolf Rapids, September, 1878	11,235	1.22
At Diamond Island, October, 1878	8,155	0.425

The following table gives the distances, fall, and rate of fall per mile of the Yellowstone:

Sketch of river.	Distance in miles.	Total fall in feet.	Fall per mile in feet.
Junction City to mouth of Big Horn River	5. 3	27. 73	5. 23
Mouth of Big Horn to head of shoal below Etchetah	3. 8	12. 81	3. 37
Thence to foot of shoal below Etchetah	0. 5	4. 27	8. 54
Thence to head of Thousand Isles Shoals	1. 4	2. 27	1. 62
Thence to foot of Thousand Isles Shoals	1. 4	7. 76	5. 54
Thence to head of Earl's Rapids	1. 6	3. 97	2. 48
Thence to foot of Earl's Rapids	0. 5	4. 63	9. 26
Thence to head of shoal below Allston's Ranche	6. 4	20. 49	3. 20
Thence to foot of shoal below Allston's Ranche	0. 7	4. 63	6. 61
Thence to head of shoal below Alkali Creek	3. 1	7. 26	2. 34
Thence to foot of shoal below Alkali Creek	0. 6	4. 62	7. 70
Thence to head of shoal above mouth of Froze-to-Death Creek	0. 7	0. 57	0. 81
Thence to foot of shoal above mouth of Froze-to-Death Creek	0. 3½	2. 39	6. 83
Thence to head of shoal at Froze-to-Death Creek Station	4. 1½	12. 59	3. 03
Thence to head of Rosebud Island	1. 6	4. 79	2. 99
Thence to foot of Rosebud Island	4. 0	17. 43	4. 36
Thence to foot of Brisbur's Island	4. 0	14. 44	3. 61
Thence to head of Avenue Island Shoals	6. 9	16. 95	2. 41
Thence to foot of Avenue Island Shoals	1. 4	6. 71	4. 79
Thence to head of first shoal below Big Porcupine Creek	2. 7	7. 14	2. 64
Thence to foot of first shoal below Big Porcupine Creek	1. 0	3. 47	3. 47
Thence to head of second shoal below Big Porcupine Creek	1. 0	2. 21	2. 21
Thence to foot of second shoal below Big Porcupine Creek	1. 5	6. 72	4. 48
Thence to head of third shoal below Big Porcupine Creek	2. 4	4. 29	1. 79
Thence to foot of third shoal below Big Porcupine Creek	1. 4	7. 78	5. 56
Thence to head of shoal opposite to Basket Butte	3. 1	8. 75	2. 82
Thence to foot of shoal opposite to Basket Butte	0. 4	3. 48	8. 70
Thence to head of island above Rosebud telegraph station	5. 8	13. 16	2. 27
Thence to foot of shoal near Ash Creek	1. 0	6. 98	6. 98
Thence to head of shoal below Rosebud telegraph station	2. 1	4. 19	2. 00
Thence to foot of shoal below Rosebud telegraph station	0. 5	3. 23	6. 46
Thence to head of shoal and rapids below Rosebud Creek	1. 9	3. 30	1. 74
Thence to foot of shoal and rapids below Rosebud Creek	0. 8	5. 80	7. 25
Thence to head of shoal above Sand Creek	0. 9	1. 55	1. 72
Thence to foot of shoal above Sand Creek	0. 5	4. 04	8. 08
Thence to head of first shoal below Sand Creek	3. 6	7. 13	1. 98
Thence to foot of first shoal below Sand Creek	0. 4	2. 88	7. 20
Thence to head of second shoal below Sand Creek	1. 0	2. 65	2. 65
Thence to foot of second shoal below Sand Creek	0. 4	2. 56	6. 40
Thence to head of shoals and rapids above Custer Bluffs	4. 6	10. 97	2. 38
Thence to foot of shoals and rapids above Custer Bluffs	1. 1	8. 04	7. 31
Thence to head of shoal at Benteen's Island	9. 2	20. 66	2. 25
Thence to foot of shoal at Benteen's Island	1. 0	6. 92	6. 92
Thence to head of shoal at Kellogg's Creek	2. 4	4. 29	1. 78
Thence to foot of shoal at Kellogg's Creek	1. 7	6. 53	3. 84
Thence to head of shoal above telegraph crossing above Fort Keogh	3. 2	8. 75	2. 73
Thence to foot of shoal above telegraph crossing above Fort Keogh	0. 6	4. 97	8. 28
Thence to head of shoal at ferry crossing at Fort Keogh	2. 1	5. 36	2. 55
Thence to foot of shoal at ferry crossing at Fort Keogh	0. 6	3. 32	5. 53
Thence to old ferry crossing above mouth of Tongue River	3. 9	15. 45	3. 96
Thence to ferry at Keogh to head of Buffalo Rapids	12. 38	48. 937	3. 95
Thence from head of Buffalo Rapids to foot of Buffalo Rapids	7. 803	7. 699	9. 87
Thence from foot of Buffalo Rapids to head of Baker's Rapids	18. 0602	69. 262	3. 83
Thence from head of Baker's Rapids to foot of Baker's Rapids	. 712	5. 162	7. 25
Thence from foot of Baker's Rapid to head of Wolf Rapids	6. 767	21. 526	3. 18
Thence from head of Wolf Rapids to foot of Wolf Rapids	. 42	4. 226	10. 06
Thence from foot of Wolf Rapids to head of McEwen's Rapids	3. 9	13. 873	3. 55
Thence from head of McEwen's Rapids to foot of McEwen's Rapids	. 25	2. 262	9. 048
Thence from foot of McEwen's Rapids to 300 feet below head of White Sand Rapids	9. 227	20. 674	2. 24
Thence from 300 feet below head of White Sand Rapids to foot of White Sand Rapids	. 1534	1. 519	9. 928
Thence from foot of White Sand Rapids to head of De Russy's Rapids	10. 0303	24. 596	2. 452
Thence from head of De Russy's Rapids to foot of De Russy's Rapids	. 5985	2. 288	3. 83
Thence from foot of De Russy's Rapids to 930 feet below head of Walker's Island Shoal	4. 1316	7. 467	1. 807
Thence from 930 feet below head of Walker's Island Shoal to foot of Walker's Island Shoal	. 57	2. 83	4. 965
Thence from foot of Walker's Island Shoal to head of Monroe Rapids	7. 4917	23. 301	3. 11
Thence from head of Monroe Rapids to foot of Monroe Rapids	. 309	1. 248	4. 04
Thence from foot of Monroe Rapids to head of Reno's Bend	38. 7708	104. 397	2. 69
Thence from head of Reno's Bend to foot of Reno's Bend	. 8958	5. 174	5. 77
Thence from foot of Reno's Bend to head of Beef Slough	12. 522	34. 852	3. 29
Thence from head of Beef Slough to foot of Beef Slough	1. 15	5. 316	46. 22
Thence from foot of Beef Slough to foot of Diamond Island	16. 137	31. 881	1. 976
Total	256. 4566	811. 37	3. 16

R 4.

EXAMINATION AND SURVEY OF CHEYENNE RIVER.

The Cheyenne River has two main branches, the South Fork and the North Fork or Belle Fourche. These streams have their sources west of, and inclose, the territory known as the Black Hills. The former drains the southwestern, southern, and southeastern; the latter, the northwestern, northern, and northeastern slopes of the hills. Warren says: "These forks are supplied by numerous streams from the mountains, and they unite in about longitude 102° 20', the river flowing into the Missouri in latitude 44° 48'."

The Belle Fourche, at the crossing of the Bismarck and Fort Meade stage route is a swift, clear stream about 1 foot in depth and with a gravel bed.

Raynolds crossed the same stream at another point, and describes it as follows:

> The river here is a clear, beautiful stream about 30 yards in width and 2 feet deep, flowing over a stony or gravel bottom.

Ludlow refers to his two crossings of the stream as follows:

> The Belle Fourche or North Fork of the Cheyenne has a rapid current in a shaly bed 30 feet to 50 feet wide and from 1 foot to 4 feet deep. We found the Belle Fourche where crossed, to be a rapid stream in a shaly and gravelly bed 80 feet wide and a foot deep.

In reference to the South Fork, Ludlow describes the river at the point where he struck it, 100 miles south of Madden's Crossing, as follows:

> We found it a shallow stream, with a flat stony and sandy bed about 30 feet wide and 5 inches deep, though evidently much broader in wet seasons.

The South Fork, from Madden's Crossing (25 miles south of the confluence to its junction with the Belle Fourche), is, with the exception of a few rapids, a lazily-running stream with an average depth of 18 inches. The water is muddy and the bed sandy.

At the junction the Belle Fourche runs slowly, with a deep channel, the South Fork shooting down over rapids. The water of the latter is muddy and alkaline, that of the former clear, saline, and of a pale green color. They each discharge about the same quantity of water. From the "forks" to its mouth the Cheyenne presents the usual characteristics of the Northwestern rivers. Its course is tortuous, impinging on steep bluffs alternately on the right and left. The bottom-lands vary in length from 3 to 10 miles, the greatest width being 1½ miles. It is exceptional to find "the bench," the bottom lands extending generally to the base of the prairie bluffs. The banks are lined with willows for a width of about 100 to 200 feet, backed by heavy timber interspersed with brush and berry and plum bushes. From the outskirts of the timber to the bluffs the open bottoms are clothed with fine grass.

The high-water bed is from 400 to 1,200 feet wide. The stream, at low-water stage, is from 100 to 130 feet broad. Near its mouth it attains a width of from 180 to 200 feet. The average depth of the channel is 2.5, but for a width of only 15 to 20 feet. Many rocky bars are encountered with a depth of only 6 to 8 inches, and a fall of 2 to 3 feet in a hundred. At the lower end snags are to be found in places obstructing the channel. There are many high-water islands, but only two low-water islands. One of the latter is only about 500 feet long and 60 to 70 feet wide; the other is about a mile long and of 1,800 feet greatest

width. The main channel at this island is from 50 to 60 feet wide, and at the upper end of the island 2 feet deep.

The average velocity of the current at low-water stage is, exclusive of rapids, about 2 inches per hour.

The bed is gravelly. At only a few points, the forks and at the mouths of creeks, is mud to be found. At the water's edge the banks are sandy.

Excessive floods would appear to be exceptional, but few places showing signs of the stream having overstepped its boundaries and encroached upon the bottom. Usually the floods due to melting masses of snow in the Black Hills commence about April and last about two months.

In 1878 the flood commenced about April 24, and the stream rose and fell alternately for about four months. Another small rise occurred at the end of September of the same year. Indians have seen the stream at a stage when the water extended from bluff to bluff. The average depth at high-water stage is about 10 to 12 feet.

Of the twenty-eight creeks tributary to the Cheyenne only ten dischaged water at the time the survey was made, and these supplied but a small amount. All of the streams are strongly alkaline. The bottoms are fertile and well adapted to agricultural purposes. The region is well stocked with game of many varieties.

HISTORY OF THE WORK.

The river and harbor act approved March 3, 1879, provided for an examination or survey of the Cheyenne River. Having been placed in charge of the work a project was submitted to the Chief of Engineers, and upon its approval the sum of $1,000 was made available for the purpose.

A party, consisting of one assistant engineer, one recorder, and two laborers, was sent from Saint Paul August 20, 1879, to Fort Meade, Dakota Territory; Capt. Leslie Smith's Company of the First Infantry was detailed as escort. The necessary subsistence supplies having been purchased and the outfit obtained from the post quartermaster of Fort Meade, the party started for Madden's Crossing August 28, 1879, arriving there August 28, having traveled a distance of 66.16 miles. The forks were reached August 30. The detailed survey was commenced at this point on September 1 and finished September 15. The work was done by stadia readings checked by azimuth and sextant observations. The levels were computed from aneroid barometer readings. In addition, odometers were attached to the escort wagon which traveled in the bottom-lands. I would here state that great credit is due Mr. J. J. Durage, assistant engineer, for the excellent and rapid work which he accomplished in the face of many hardships and difficulties. The party worked on an average 18 hours out of every 24.

The following is a summary of the work done:

Number of lines sounded	2,130
Number of soundings taken	16,680
Miles of river surveyed	115.72
Miles of developed shore line	287.44
Average daily progress in miles	7.7
Number of azimuth stations	13
Fall in feet from forks to mouth	715
Discharge in cubic feet per second	375.11

The party arrived in Saint Paul September 23, when all were discharged with the exception of the assistant engineer, who was retained to plot

the notes until November 22, when the appropriation having become exhausted he was discharged. He enlisted as topographical assistant at headquarters Department Dakota and continued the work on the maps, but owing to the many interruptions due to calls for department work the maps are not yet finished. I, however, forward herewith tracings of 11 characteristic sketches of the stream with cross-sections.

Upon inspection of these cross-sections, it will be seen that there is hardly a row-boat stage of water, to say nothing of steamboats.

It is my opinion that the Big Cheyenne must be classed as a creek and not as a river; that it is not navigable and that any attempt to render it so would prove to be an experiment so costly that the benefits to be derived would be wholly incommensurate with the outlay.

I have learned casually that two railroads are now being pushed towards the Black Hills. I can learn nothing definite, as the authorities of the roads are very reticent, but it is a well-understood fact that the Black Hills will soon be connected with the East by rail communication, and the Cheyenne could never compete for the transportation.

Therefore I would respectfully recommend that no appropriation for improving the Big Cheyenne River be asked for.

My thanks are due to Capt. Leslie Smith, First Infantry, now major, Second Infantry, for his assistance and courtsey.

APPENDIX S.

IMPROVEMENT OF THE NAVIGATION OF THE MISSISSIPPI RIVER BETWEEN SAINT PAUL AND THE MOUTH OF THE ILLINOIS, INCLUDING IMPROVEMENTS AT SPECIAL LOCALITIES BETWEEN THOSE POINTS—IMPROVEMENT OF GALENA RIVER AND HARBOR, ILLINOIS—IMPROVEMENT OF CUIVRE RIVER, MISSOURI.

REPORT OF CAPTAIN ALEXANDER MACKENZIE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 7, 1880.

GENERAL: I have the honor to transmit herewith the annual reports of operations under my charge during the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

S 1.

OPERATIONS OF SNAG-BOAT IN IMPROVEMENT OF UPPER MISSISSIPPI RIVER.

Under this head of appropriation is operated the snag and dredge boat General Barnard, whose district extends from Saint Paul to the mouth of Missouri River, a distance of 714 miles. The very complete appended report of Assistant Engineer C. W. Durham gives in detail the work of the last fiscal year, river notes of interest, a general description of the work of the snag-boat, past and prospective, and statistics of commerce and navigation.

The assistance rendered to navigation by this boat is very great, and the reliable information continually collected without additional expense is invaluable in connection with a proper system of river improvement.

Although the *General Barnard* is admirably adapted to the heavier portion of the work of this district, and is needed for the removal of the largest snags and obstructions, a number of which make their appearance each year, yet its draught is too great for use on the extreme upper river during low stages. The heavy work required of this boat can be finished in a short time each year, and for the remainder of the season a light-draught stern-wheel boat, available for use in very low water on extreme upper as well as lower part of the district, would be

much more efficient and economical. A boat of this description would cost about $15,000, but it would not increase the annual expense now attending the operation of the snag-boat in this district, and its use as a tow-boat when not employed snagging or dredging would decrease the cost attending the charter of boats in connection with the various works of improvement.

An appropriation of $25,000 for operating expenses during fiscal year ending June 30, 1882, is respectfully asked for, and this amount cannot be materially reduced without impairing the efficiency of the boat; and for constructing a light-draught stern-wheel boat to act in connection with the *General Barnard*, and especially in low-water seasons, $15,000 additional is requested.

APPROPRIATIONS.

There have been appropriated for improving Upper Mississippi River the following amounts:

By act approved March 2, 1867	$96,000
By allotment from appropriation of July 25, 1868	26,000
By act approved July 11, 1870	36,000
By act approved March 3, 1871	42,000
By act approved June 10, 1872	42,000
By act approved March 3, 1873	25,000
By act approved June 23, 1874	25,000
By act approved March 3, 1875	25,000
By act approved August 14, 1876	30,000
By act approved June 18, 1878	41,500
By act approved March 3, 1879	20,000
By act approved June 14, 1880	8,000
Total	416,500

Money statement.

July 1, 1879, amount available	$17,707 78	
Amount appropriated by act approved June 14, 1880	8,000 00	
		$25,707 78
July 1, 1880, amount expended during fiscal year		13,867 26
July 1, 1880, amount available		11,840 52
Amount that can be profitably expended in fiscal year ending June 30, 1882.		40,000 00

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1880.

CAPTAIN: I have the honor to present my annual report on improving Upper Mississippi River for the fiscal year ending June 30, 1880, together with some statistics of commerce and navigation.

OPERATIONS OF THE UNITED STATES SNAG AND DREDGE BOAT GENERAL BARNARD.

The operations of the *General Barnard* in 1879, prior to July 1, have already been reported to your predecessor, Maj. F. U. Farquhar, Corps of Engineers. From that time to October 16 she was employed as heretofore between Saint Paul and the mouth of the Missouri River, in removing snags, impending trees, wrecks, &c., dredging, assisting steamboats, establishing water-gauges, buoys, and channel marks, making surveys and reconnaissances, transporting government property, and rendering occasional service to the works of permanent improvement. From October 16 to 20, a portion of the crew was engaged in laying her up in winter quarters at Quincy, Ill.

During the season noteworthy service was performed at several localities, among which may be mentioned the removal of snags at or near Warsaw, Oquawka, Gilbert's Chute, Armstrong Island, Slim Island, Westport Chute, Missouri Point, Turner's Landing, Fox River, Missouri River, Cassville Slough, and Prescott, and also of wrecks at Buffalo and Cincinnati Landing.

SUMMARY OF OPERATIONS OF STEAMER GENERAL BARNARD, SEASON OF 1879.

Snags removed	547
Wrecks removed	3
Leaning trees pulled back	122
Leaning trees felled	4,421
Buoys placed	3
Dredging, days	6
Steamboats assisted and pulled off bars	18
Water-gauges established	1
Channel-marks established	6
Miles run	7,167

The *General Barnard*, in charge of the Mississippi River Commission, also made a trip of inspection to New Orleans and the jetties, leaving Quincy on November 12, and returning to Saint Louis December 15. On account of the great amount of floating ice in the river and the severity of the weather, it was found impracticable to return her to Quincy, and she was accordingly laid up at Bushburg, Mo., some 25 miles below Saint Louis, on December 16. In making this trip she ran 3,153 miles.

Prior to starting from Saint Louis on the above-mentioned cruise, the Barnard ran down to Carondelet, raised a sunken steam launch belonging to the government, and rescued the United States Coast Survey steamer Hitchcock from a very perilous position on the piling at Horsetail Bar.

Here follows a summary of operations from 1877 to 1879, inclusive; a summary from 1868, the year in which the work was initiated, to 1876, is published in report of Chief of Engineers for 1877, part 1, page 527.

Summary of snag and dredge boat operations from 1877 to 1879, inclusive.

	Snags extracted.	Leaning trees removed.	Days dredging.	Steamboats, barges, and rafts pulled off bars.	Wrecks removed.	Miles run.	
Season of 1877. *Montana.*	94	6,526	3	18	......	4,482	Also established 150 island numbers, 19 channel-marks, 2 water-gauges, and 45 bench-marks. Made 4½ miles of hydrographic surveys.
Season of 1878. *Montana.*	152	3,980	1	7	......	4,997	Also established 2 channel-marks, 28 water-gauges, 29 bench-marks. Rock removed from channel, 23 cubic yards; rock put in dams, 85 cubic yards. Made 12 miles hydrographic survey. *Barnard* built in winter.
Season of 1879. *General Barnard.*	547	4,543	6	18	3	7,167	Established 3 buoys and 6 channel-marks. Ran 3,153 additional miles with Mississippi River Commission.

During March, 1880, the *General Barnard* was brought from Bushburg, Mo., to Rock Island, and having been repainted and thoroughly repaired, is now ready for service.

RIVER NOTES.

During the spring of 1879, the river from Saint Paul to the mouth of the Illinois remained at very low stage as it had been during the winter, but owing to the scour on the reefs incidental to protracted low-water, the channel was well defined and little trouble was experienced from stranding except at Gilbert's Island. A small rise occurred in the latter part of May, the river falling again in June. About July 1 another

rise began, and during this month the river was at an excellent boating stage. From August 1 to the end of the season the water continued very low and navigation was much impeded. The large side-wheel packets were laid up and their places supplied by stern-wheel boats of very light draught, and most of these could go no farther up the river than Red Wing. Even the small steamboats used for rafting experienced great difficulty in reaching their destinations and some of these were compelled to lay up. During the spring and summer of 1880 up to the time of writing the stage of water in the river has continued very favorable to navigation. I give a list of channel depths on some of the worst bars at the low-water periods of 1879: Prescott, 1 foot 6 inches; Smith's, 2 feet 6 inches; Head of Lake Pepin, 3 feet; Wabasha, 2 feet 8 inches; Crat's, 3 feet; Beef Slough, 2 feet 8 inches; La Crosse, 3 feet; Cassville Slough, 3 feet; Bellevue, 2 feet 9 inches; Warsaw, 4 feet 6 inches; Gregory's, 4 feet 6 inches; Quincy, 4 feet; Gilbert's Island, 3 feet 6 inches; Slim Island, 4 feet 6 inches; Westport Chute, 4 feet 6 inches.

The following table shows an observed channel depth on the worst bars in different seasons, and the stage of the river at the time of the observation, from which we estimate and give the *theoretical* depth at extreme low-water. The *actual* depth at low-water would be generally somewhat greater than the depth given, owing to the scour on the reefs which takes place when the water reaches a very low stage;

Year.	Locality.	Observed depth.	Stage of river above low-water of 1864.	Calculated low-water depth.	Remarks.
		Feet.	*Feet.*	*Feet.*	
1874	Frenchman's	7.8	5.9	1.9	
1878	......do	2.4	1.4	1.0	
1866	Pig's Eye	3.2	2.0	1.2	
1874		5.7	4.4	1.3	
1878		7.4	3.4	4.0	After improvement.
1866	Kaposia	3.2	2.0	1.2	
1874	......do	6.3	5.3	1.0	
1878	......do	5.4	3.4	2.0	
1866	Newport	4.0	3.0	1.0	
1877	......do	2.8	0.8	2.0	
1878	......do	5.3	3.4	1.9	
1866	Nininger Slough	4.0	3.0	1.0	
1877	......do	5.0	1.3	3.7	After improvement.
1878	......do	7.7	4.0	3.7	Do.
1866	Prescott	4.4	3.0	1.4	
1874	......do	6.2	4.5	1.7	
1877	......do	3.0	1.3	1.7	
1878	......do	6.5	5.0	1.5	
1877	Smith's	3.0	1.3	1.7	
1878	......do	3.0	1.0	2.0	
1879	Smith's (summer)	2.5	1.2	1.3	
1879	Smith's (fall)	5.0	2.2	2.8	Partial improvement.
1877	Diamond Bluff	3.0	1.3	1.7	
1878	......do	3.3	0.8	2.5	
1866	Head Lake Pepin	3.9	1.5	2.4	
1874	......do	8.2	5.2	3.0	
1878	......do	2.9	0.6	2.3	
1866	Beef Slough	4.0	2.0	2.0	
1874	......do	5.5	3.5	2.0	
1877	......do	2.5	1.4	1.1	
1879	......do	2.7	1.0	1.7	
1866	Mount Vernon	3.0	1.0	2.0	
1874	......do	5.5	2.5	3.0	
1877	......do	3.5	1.4	2.1	
1878	......do	4.0	1.9	2.1	
1877	Chimney Rock	3.0	1.4	2.1	
1877	Rollingstone	2.5	1.4	1.1	
1866	Betsy Slough	3.5	2.0	1.5	
1874	......do	4.0	2.1	1.9	
1877	......do	3.5	1.4	2.1	
1878	......do	3.3	1.7	1.6	
1866	Winona	4.0	2.0	2.0	
1877	......do	4.5	1.4	3.1	
1878	......do	3.0	1.5	1.5	
1879	......do	2.8	1.0	1.8	
1866	Queen's Bluff	6.0	3.5	2.5	
1877	......do	3.0	1.5	1.5	
1878	......do	3.0	1.3	1.7	

Year.	Locality.	Observed depth.	Stage of river above low-water of 1864.	Calculated low-water depth.	Remarks.
		Feet.	*Feet.*	*Feet.*	
1878	Queen's Bluff	5.2	1.6	3.6	After improvement.
1877	La Crosse	3.5	1.5	2.0	
1879	......do	3.0	1.0	2.0	
1875	Cassville Slough	6.0	3.5	2.5	
1877	......do	3.5	1.2	2.3	
1878	......do	5.0	3.1	1.9	
1875	Bellevue	6.0	4.5	1.5	
1877	......do	3.0	1.4	1.6	
1878	......do	5.5	3.0	2.5	
1879		4.0	1.9	2.1	
1877	Sand Prairie	3.0	1.4	1.6	
1877	Below Burlington	3.5	1.1	2.4	
1877	Below Fort Madison	3.3	1.0	2.0	
1879	Montrose	4.7	2.1	2.6	
1877	Warsaw	3.8	1.9	1.9	
1878	Wyaconda	5.0	3.4	1.6	
1879	Quincy	7.1	3.7	3.4	
1879	Gilbert's Island	5.0	2.3	2.7	
1877	Slim Island	3.0	1.0	2.0	
1879	......do	6.2	2.2	4.0	
1877	Westport Chute	3.0	1.0	2.0	
1879	......do	8.0	2.7	5.3	

WORK OF THE SNAG-BOAT.

It may be proper at this time to say a few words concerning the work of the snag-boat, past and prospective.

SNAGGING.

In former years the number of snags in the river was much greater than at present, being of long accumulation, but by degrees the most of these have been removed, and there are now but few snags and wrecks of long standing, endangering navigation.

Additions are made from year to year, and especially in times of high-water, from caving banks, and many are brought in from tributary streams, and again where the channel, changing, goes down some hitherto unnavigated chute or cuts through some sand-bar perhaps based on a nucleus of snags; many obstructions of this kind are met with. The policy of removing and destroying the large trees near the edge of the banks, thereby preventing them from falling in and becoming dangerous snags, has been followed for several years, and careful attention to this matter has greatly decreased the annual quota. The snagging work, however, although not as arduous as formerly, still requires and should receive each year careful attention. Under this head may also be placed the work performed by the snag-boat in removing stumps and other *débris* deeply imbedded in mud and sand on and near the banks, where shore protections are proposed, thereby greatly faciliating the proper construction of this needful work. The snag-boat will be much in request for this class of work in the future.

IMPENDING TREES.

These occur and are removed in large numbers every year, being, as they are, of great annoyance and danger to navigation in the narrow chutes, and more especially in the deep bends and where the channel closely hugs the bank.

DREDGING.

A Long's scraper has always formed a part of the equipment of the snag-boat on the Upper Mississippi, and with this apparatus a large amount of work was performed for several years in deepening the water on the crests of the bars above Winona, but the results not being commensurate with the amount of time and labor required, comparatively little of this kind of work has been done of late years. So many bars scattered over the entire 700 miles of river, becoming obstructions simultaneously at each recurring low-water, it was found a hopeless task to keep them all open with one boat,

and unless a channel is cut through *all* and *maintained*, the work cannot be considered successful. And again, the results have no permanency, the work of the scraper being generally obliterated at each rise of the river, however slight, and in many cases a single night will destroy the work of the previous day. In increasing the depth on a bar for the time being the scraper is generally very effective and is now often used in special cases where it is thought that a channel once cut will maintain itself. As an adjunct to the dams and jetties in hastening and assisting their operation and in determining the course of the improved channel, the scraper may be made of great utility, as under these circumstances it is believed that the channel will be permanently maintained by the action of the dams, and in hard bottoms beneficial results will be more quickly secured. A great deal of this work is proposed for the future.

REMOVAL OF ROCK.

The snag-boat has at various times removed dangerous rocks and bowlders from the channel, and some of this work remains to be done as occasion permits.

WRECKS.

Many wrecks have been removed by the snag-boat in former years, and several dangerous ones still remain for future operations.

ASSISTING STEAMBOATS, ETC.

It has always been the practice of the snag-boat to render assistance to stranded steamboats and rafts which may be considered as forming an impassable obstruction to navigation in this narrow and shallow river, lying directly in and filling up the main channel, as they usually do when found in this predicament.

SURVEYS AND RECONNAISSANCES.

In cases of emergency, and when it was deemed inexpedient to form a special party for the purpose, the crew of the snag-boat has been employed in making examinations and surveys at special localities. Many harbor surveys have been executed in this manner, as also a part of the general survey of 1878, and a reconnaissance of the bars below Keokuk in 1877.

A general surveillance of the river is kept up while the boat is in commission, and notes and soundings are taken at the various bars, which furnish useful data for studying their conditions.

DAMS AND REPAIRS.

Dams were built by the snag-boat at Pig's Eye in 1874, at Nininger Slough in 1875 and 1876, and these were the first experiments of the kind on the Upper Mississippi, the results being eminently successful.

To maintain in good repair the dams and shore protections now constructed, in process of construction, and proposed, will constitute a fruitful source of important and needful work, and will properly fall to the lot of the snag-boat. Although it will probably become necessary in the future to employ for this purpose a light-draught stern-wheel tow-boat, yet the snag-boat, if supported by Congress, will be competent for this work for several years to come.

IN GENERAL.

There are many other features of the work of the snag-boat worthy of mention. In 1877 the enumeration of the channel islands was performed by it, and boards with the proper number were placed on a great many of them. In 1878 a system of water-gauges for ascertaining the fluctuations of water surface was established. In shallow crossings buoys are often placed to guide steamboats, and channel marks or ranges on shore for the same purpose; and in cases of this kind, and also at localities where boats are frequently stranded, examinations are made and great care is taken to discover and properly mark the most feasible channel. The snag-boat has been, and may in the future often be, required in transporting government property, towing flats in aid of works of construction, conveying survey and construction parties to their destinations, for trips of inspection, in assisting the Light-House Service, and by the Mississippi River Commission, it being the only government boat on the upper river. It would seem proper, then, in view of the manifold duties of the *General Barnard*, and the benefit to steamboats and general navigation derived from her services, that she should be liberally supported, and to the full amount asked for by you.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

STATISTICS OF COMMERCE AND NAVIGATION.

Lumber.

The most important business interest on the Upper Mississippi and its principal tributaries is the lumber trade, giving employment to great numbers of men and more than 100 steamboats, which are used in guiding and propelling rafts. Between the mouth of the Chippewa and Saint Louis there are 73 mills on the main river, with an annual *day* sawing capacity of 600,000,000 feet, employing some 12,000 men and representing about $12,000,000 of capital. The estimated product of white pine floated into the Mississippi River in 1879 was 1,500,000,000 feet, including logs, lumber, shingles, &c.; in 1878, 900,000,000 feet; in 1877, 750,000,000 feet; in 1876, 1,350,000,000 feet.

The following table shows the amount of lumber manufactured on the Upper Mississippi and tributaries in 1879 and 1878 and the amount on hand January 1, 1880:

Table showing lumber business of Upper Mississippi River and tributaries for 1879 and 1878.

Names, localities, &c.	Lumber manufactured.		On hand January 1, 1880.
	1879.	1878.	
	Feet.	*Feet.*	*Feet.*
W. D Washburn & Co., Farnham & Lovejoy, Camp & Walker, and twenty-three other firms at Minneapolis and above	193, 688, 555	138, 913, 130	115, 000, 000
Laird, Norton & Co., W. and J. Fleming, Youmans Bros., and nine other firms between Minneapolis and Dubuque	77, 629, 000	41, 300, 000	46, 000, 000
Ingram, Kennedy & Day, Dubuque Lumber Company, and two other firms at Dubuque	23, 750, 000	18, 725, 000	9, 000, 000
W. J. Young & Co., C. Lamb & Sons, and six other firms at Clinton, Lyons and Fulton	120, 924, 000	63, 697, 915	60, 000, 000
Meyerhaueser & Denkmann, Dimock, Gould & Co., and nine other firms at Rock Island, Davenport, and Moline	115, 042, 000	56, 215, 000	54, 000, 000
Hershey Lumber Company, P. M. Musser & Co., and seven other firms below Davenport	106, 200, 000	51, 850, 553	38, 000, 000
Schulenburg, Boeckler & Co., Hersey, Bean & Brown, and ten other firms on the Saint Croix River	109, 000, 000	58, 520, 000	18, 000, 000
Eau Claire Lumber Company, Daniel Shaw & Co., and ten other firms on the Chippewa	260, 000, 000	128, 000, 000	56, 000, 000
John Paul, La Crosse Lumber Company, and eight other firms on Black River	66, 165, 000	35, 202, 000	22, 000, 000
Mills unreported, twenty-one firms, say	50, 000, 000		
Total for Mississippi and tributaries, 125 firms	1, 122, 398, 555	592, 423, 598	418, 000, 000

The product of the Wisconsin River is omitted from the above statement, inasmuch as nearly all the lumber made on that river is shipped by rail.

In order to show the entire lumber business of the Upper Mississippi Valley for the past five seasons, is given the following

Summary.

Locality.	Lumber manufactured.				
	1879.	1878.	1877.	1876.	1875.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Main river	687, 233, 555	370, 701, 598	456, 840, 424	629, 967, 000	555, 397, 000
Saint Croix	109, 000, 000	58, 520, 000	53, 341, 030	66, 793, 000	75, 520, 000
Chippewa	260, 000, 000	128, 000, 000	157, 046, 678	255, 866, 999	264, 077, 000
Black	66, 165, 000	35, 202, 000	49, 250, 000	70, 852, 747	62, 000, 000
Wisconsin	152, 177, 025	193, 039, 314	143, 523, 000	154, 700, 000	118, 000, 000
Aggregate	1, 274, 575, 580	785, 462, 912	860, 001, 132	1, 178, 179, 746	1, 074, 994, 000

Receipts at Saint Louis from Upper Mississippi River.

	1879.	1878.	1877.
White pine lumber and logs ... feet	179, 919, 105	129, 806, 733	163, 304, 150
Shingles ... pieces	77, 811, 500	88, 059, 500	64, 919, 000
Laths ... do	27, 713, 700	29, 414, 500	15, 973, 200

STEAMBOATS AND FREIGHT.

The principal steamboat lines on the Upper Mississippi River are the Keokuk Northern and Diamond Jo. There are also some independent boats carrying freight and passengers. The total amount of freight carried by these two lines was in 1877, 279,098 tons; in 1878, 430,000 tons; in 1879, 411,862 tons.

Statement of amount of freight received at and shipped from Saint Louis by the Upper Mississippi River for six years.

	1879.	1878.	1877.	1876.	1875.	1874.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Received	221, 285	174, 065	136, 715	224, 860	198, 100	231, 060
Shipped	66, 990	67, 320	68, 565	93, 360	96, 225	95, 800
Total carried	288, 275	241, 385	205, 280	318, 220	294, 325	326, 860

Table showing aggregate receipts at Saint Louis from Upper Mississippi River in 1879.

Articles.	Quantity.	Articles.	Quantity.
Apples ....barrels..	38, 411	Iron and steel ....tons..	312
Barley .... sacks..	117, 584	Lard ....pounds..	249, 190
Barley ....bushels..	60, 861	Lead ....pigs..	2, 904
Beans ....sacks..	601	Leather ....rolls..	421
Bran ....do ...	2, 215	Malt ....sacks..	380
Butter........................pounds ..	76, 180	Merchandise and sundries .packages..	160, 813
Cattle .... head..	9, 279	Oats .... sacks..	383, 326
Cement.......................barrels..	165	Oats .... bushels..	37, 293
Cheese..........................boxes..	736	Oils..............................barrels..	446
Cooperage ....flour..	47	Onions ....packages..	27, 439
Cooperage .... pork..	2, 232	Peltries ....do	987
Cooperage ....whiskey..	379	Pork ....barrels..	5, 264
Cooperage .... lard	6, 688	Pork, hams ....pounds..	290, 389
Cooperage ....meat casks..	4, 670	Pork, meats .... do....	1, 783, 737
Corn ....sacks..	187, 032	Potatoes ....packages..	73, 792
Corn ....bushels..	68, 222	Rye ....sacks..	40, 812
Corn-meal ....barrels..	1, 224	Seeds .... do....	3, 544
Dried fruit ....packages..	333	Sheep .... head..	8, 928
Eggs ....do....	2, 816	Tallow ....pounds..	557, 645
Fish ....do....	1, 140	Tobacco ....hogsheads..	1, 533
Flour ....barrels..	73, 896	Tobacco ....packages..	45, 291
Grease ....pounds..	170, 800	Wheat .... sacks..	277, 824
Hay .... bales..	93, 765	Wheat ....bushels..	36, 000
Horses and mules ....head..	3, 628	Wines and liquors ....barrels..	652
Hides ....pounds..	373, 690	Wines and liquors ....boxes..	373
Hogs ....head..	32, 182	Wool ....pounds..	339, 346

There follow some statements, in all cases partial, tending to show amount of commerce and manufactures of a number of the cities on the river in 1879.

SAINT PAUL, MINNESOTA.

Sales and transfers during first eleven months of 1879.

Grain ....value ..	$5, 225, 000
Dry goods ....do....	5, 000, 000
Groceries ....do....	4, 900, 000
Agricultural implements ....do....	2, 100, 000
Commission merchants ....do....	2, 000, 000
Boots and shoes ....do....	2, 000, 000
Hides, pelts, &c ....do....	1, 875, 000
Hardware ....do....	1, 450, 000
Drugs ....do....	1, 175, 000
Lumber ....do....	900, 000
Flour ....do....	1, 100, 000
Cigars and tobacco ....do....	900, 000
Wines and liquors ....do....	875, 000
Books and stationery ....do....	750, 000

Coal	value..	$750,000
Iron, steel, &c	do....	650,000
Hats, caps, and furs	do....	575,000
Clothing	do....	400,000
Beer and ale	do....	400,000
Mill machinery, &c	do....	385,000
Fruits	do....	375,000
Leather	do....	350,000
Confectionery	do....	350,000
Crockery	do....	325,000
Saddlery	do....	300,000
Pork	do....	300,000
Carpets	do....	275,000
Millinery	do....	225,000
Furniture	do....	200,000
Total		$36,110,000

DUBUQUE, IOWA.

River receipts.

Merchandise, including iron, wood stuffs, cordage, &c	pounds..	127,000,000
Lumber	feet..	73,000,000
Oats	pounds..	18,969,000
Wheat	do...	866,700
Flour	do...	251,000
Butter	do...	190,000
Lead	do...	2,200,000
Cattle	head..	3,470
Salt	pounds..	16,500
Cement	do...	8,400
Staves	M..	1,300,000
Coal	pounds..	24,461,637
Passengers landing		12,397
Steamboats landing	times..	1,081

River shipments.

Merchandise, flour, butter, nails, glass, wood in shape, iron, &c	pounds..	7,561,000
Oats	do...	37,391,762
Wheat	do...	4,917,740
Corn	do...	2,260,400
Pork	do...	3,460,000
Lead	do...	2,987,142
Cement	barrels..	4,420
Lumber	feet..	1,149,000

MOLINE, ILLINOIS.

Manufactures.

Agricultural implements	value..	$2,850,000
Wagons	do...	500,000
Malleable iron	do...	250,000
Machinery	do...	283,000
Paper	do...	250,000
Scales	do...	25,000
Pumps	do...	112,500
Organs	do...	25,000
Lumber	feet..	23,062,902
Shingles	pieces..	2,128,000
Lath	do...	3,420,000
Pails	number..	450,000
Washboards	do...	80,000
Churns	do...	14,700
Tubs	do...	85,000

DAVENPORT, IOWA.

Freight.

By Chicago, Rock Island and Pacific Railroad	cars	32,432
By Chicago, Milwaukee and Saint Paul Railroad	do	6,441
By Keokuk Northern Packet Company	tons	12,477
Grain and produce:		
Wheat	bushels	1,364,105
Corn	do	609,816
Rye	do	28,165
Onions	do	118,886
Barley	do	1,141,956
Oats	do	462,669
Potatoes	do	337,734

Manufactures.

Agricultural implements	value	$450,000
Boots and shoes	do	45,000
Brass goods, &c	do	10,000
Bricks	do	28,000
Books and stationery	do	98,000
Brooms	do	13,900
Candles	do	113,200
Carriages	do	89,000
Cigars	do	168,000
Clothing	do	103,400
Crackers	do	96,700
Furniture	do	264,000
Furs	do	18,000
Beer	do	191,200
Sundries	do	1,078,700
Flour	barrels	131,500
Glucose	do	70,700
Grape sugar	do	1,294,000
Sirup	gallons	27,000
Lumber	feet	46,100,000
Shingles	pieces	8,789,000
Lath	do	10,445,000

ROCK ISLAND, ILLINOIS.

Manufactures.

Agricultural implements	value	$1,000,000
Glass	do	$200,000
Stove	do	$60,000
Mineral waters	do	$25,000
Coal mined	do	$400,000
Lumber	feet	43,428,000
Shingles	pieces	4,867,000
Lath	do	9,206,000
Pickets	do	26,000
Beer	barrels	26,000
Malt	do	40,000

Freights.

By Keokuk Northern Line Packet Company	tons	11,828
By Diamond Jo Line	do	5,000

MUSCATINE, IOWA.

Manufactures, receipts, and shipments.

Lumber	feet	51,000,000
Lath	pieces	16,000,000
Shingles	do	15,000,000

Pickets	pieces..	250,000
Washboards	number..	23,400
Packing-boxes	do...	50,000
Flour	barrels..	48,000
Cans	number..	500,000
Brick	do...	2,700,000
Pipes	gross..	33,800
Wagons	number..	600
Wagon brakes	do...	9,000

KEOKUK, IOWA.

River shipments.

General merchandise	tons..	7,850
Hay	bales..	29,600
Horses and mules	head..	987
Beeves	do...	1,042
Hogs	do...	944
Sheep	do...	361
Chickens	dozen..	2,600
Eggs	do...	52,200

River receipts.

General merchandise	tons..	6,437
Lumber	feet..	8,000,000

WARSAW, ILLINOIS.

River shipments.

Hay	bales..	45,596
Oats	bushels..	56,892
Corn	do...	32,340
Rye	do...	2,550
Apples	barrels..	9,317
Wine and cider	do...	1,872
Cooperage	pieces..	35,000
Flour	barrels..	34,124
Stock (cattle and hogs)	head..	2,108
Plows	number..	4,100
Wagons	do...	350

HANNIBAL, MISSOURI.

Manufactures, receipts, and shipments.

Lumber	feet..	124,630,145
Shingles	pieces..	55,437,000
Laths	do...	33,657,300
Salt	barrels..	200,000
Oil	gallons..	1,250,000
Lime	barrels..	230,000
Wheat	bushels..	1,000,000
Flour	barrels..	200,000
Stock	head..	25,000

The following table affords a comparative view of the relative amount of navigation at various localities on the Upper Mississippi River for the last three seasons:

Statement of steamers, barges, and rafts passing various bridges.

Locality of bridge.	Steamboats.			Barges.			Rafts.		
	1879.	1878.	1877.	1879.	1878.	1877.	1879.	1878.	1877.
Hastings	2,468	(*)	(*)	397	(*)	(*)	54	(*)	(*)
Winona	3,760	2,948	(*)	1,362	1,115	(*)	1,889	863	(*)
La Crosse	2,827	2,095	(*)	779	842	(*)	1,077	594	(*)
Dubuque	2,894	2,139	1,801	(*)	884	816	801	694	642
Clinton	2,643	1,950	2,174	996	913	633	590	†383	†352
Rock Island	2,514	1,643	1,560	750	613	790	571	352	413
Burlington	1,251	1,318	1,139	662	624	431	367	254	†155
Keokuk	1,562	1,519	1,294	851	781	572	(‡)	(‡)	(‡)
Quincy	(*)	1,450	(*)	(*)	524	(*)	(*)	191	(*)
Hannibal	1,586	1,393	1,467	884	549	585	260	156	181
Louisiana	1,856	1,390	1,331	704	545	425	120	89	106

* No record furnished. † Partial record. ‡ No record of rafts.

LIST OF STEAMBOAT ACCIDENTS ON UPPER MISSISSIPPI RIVER, SEASON OF 1879.

June 18.—Steamer Le Claire collided with the Victory; the former sunk; loss, $1,600.

July 4.—A barge in tow of steamer Josie struck a rock at Horse Island and sunk; raised; loss, $2,000.

July 13.—Steamer Victory sunk a barge on the chain above Des Moines Rapids Canal; raised.

August 4.—Barge Abe sunk at Cincinnati Landing; total loss.

August 25.—Steamer War Eagle was somewhat injured by striking a rock above Gregory's Landing.

September 3.—Steamer Annie sunk a barge on the chain above the canal.

October 12.—Steamer Iowa struck a rock opposite Dallas and sunk; raised; one man lost.

November 26.—Steamer Annie sunk a barge below Keokuk; cargo and barge total loss.

CUSTOMS REVENUE AND TONNAGE.

That portion of the Mississippi between Saint Paul and the mouth of the Illinois River lies partly in the customs district of Minnesota and partly in the customs district of New Orleans. Surveyors of customs are located at Burlington and Dubuque, Iowa, Galena, Ill., Saint Paul, Minn., and La Crosse, Wis.

In the following statement is given the *total* exhibit of the port of Saint Louis, where the greater portion of the Upper Mississippi boats are registered, and which includes many of the Lower Mississippi, Missouri, and Illinois River boats.

Customs revenue and tonnage for fiscal year ending June 30, 1879.

Port.	Collections.	Tonnage enrolled.	Remarks.
			Vessels.
Saint Louis	$1,136,417 85	148,692.68	375
Burlington	1,820 88	5,805.94	41
Dubuque	9 10	4,396.71	45
La Crosse	None	802.31	13
Galena	4,715 48	1,722.13	19
Saint Paul	11,683 71	4,731.66	50

INTERNAL REVENUE.

There are ten internal revenue districts bordering on the Mississippi River between Saint Paul and the mouth of the Illinois River. Each of these districts is composed of a large number of counties the greater portion of which do not touch the river, but

the bulk of the revenue to the government comes from the sections bordering upon the river and tributary to its navigation and commerce. I give below a table showing the designation of the districts touching the river between the points above named, the residence of the collector, and the amount of collections for the fiscal year ending June 30, 1879.

District.	Residence of collector.	Amount collected for year ending June 30, 1879.
First Minnesota	Rochester	$93,850 49
Second Minnesota	Saint Paul	211,858 27
Second Wisconsin	Madison	145,468 47
Sixth Wisconsin	Sparta	89,982 42
Second Iowa	Davenport	276,592 17
Third Iowa	Dubuque	298,663 81
Fourth Iowa	Burlington	172,116 54
Third Illinois	Mount Carroll	809,835 58
Fourth Illinois	Quincy	967,731 85
Fourth Missouri	Louisiana	280,062 47
Aggregate		3,346,162 07

Respectfully submitted.

C. W. DURHAM,
Assistant Engineer.

A. MACKENZIE,
Captain of Engineers.

S 2.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM SAINT PAUL TO DES MOINES RAPIDS.

Under this appropriation are carried on works for the improvement of through navigation. These works consist of brush and stone dams for closing side chutes and subsidiary channels, and for contracting the width of water way, and also of brush and stone shore protections for caving banks.

A general plan with estimates has been prepared, but it is liable to so many alterations of detail due to changes of the river and experience gained as the work progresses, that it is deemed more proper to simply present projects from year to year for the work which can be accomplished with the amounts then available, selecting for improvement the points known to be most troublesome. The results already obtained show that the system of improvement adopted will give in time a good channel sufficient for all purposes of navigation, and the main question of the future is a reduction in the expense of dams and shore protections, and the adoption of temporary expedients for assisting navigation until the channel is so regulated that it will maintain itself.

Previous to 1878 improvements had been made at Pig's Eye (1874) and Nininger Slough (1875 and 1876). During 1878 and 1879 works were carried on at Pig's Eye, Newport, Hastings, Prescott, Crat's Island, Beef Slough, Rollingstone, Betsy Slough, Queen's Bluff, Bellevue, Horse Island, Dallas, and Pontoosac, and during the last fiscal year improvements have been made at Hastings, Prescott, Smith's Bar, Crat's Island, Beef Slough, Mount Vernon, Rollingstone, Betsy Slough, Winona, La Crosse, Cassville Slough, Horse Island, Smith's Island, and Keithsburg.

The appended reports of United States Civil Engineer M. Meigs and Assistant Engineers E. F. Hoffman and J. L. Gillespie give in detail the work done and results obtained in their respective districts. To

these gentlemen much credit is due for the intelligence and energy they have displayed in carrying on the works assigned to their local charge.

The act of Congress approved March 3, 1879, provided that of the $100,000 appropriated for "improving Mississippi River, Saint Paul to Des Moines Rapids," $20,000 might be used for testing the Adams Flume. Mr. Adams has selected the very troublesome bar below Read's Landing for his experiments, but has not yet commenced active operations.

The work of the last season was carried on principally by contract, and this system will be recommended whenever practicable, but in many cases the river is liable to such frequent changes that the projects, which are necessarily made some time in advance of operations, cannot be adhered to, and in such cases formal contracts are inexpedient, as no plans or specifications can be drawn to properly cover the work.

While past experience has not demonstrated that the use of an ordinary dredge-boat is as a rule advisable in connection with the cutting of new channels through sand bars, yet occasions have arisen and will continue to arise where such work will be necessary. For such cases, as well as in connection with the improvement of the various harbors along the river, and in the removal of gravel bars both for improvement of navigation and for obtaining material for dams and shore protections, many dredges are required. There are but four private dredges on the river, and these being in comparatively poor condition are entirely inadequate to the prompt and proper execution of the work now required of them. The United States should own a dredge capable of removing all classes of material met with in this section of the river. Its cost, together with the requisite supply of dump-boats, &c., would not exceed $15,000.

The field work of the general survey of the river was completed in the latter part of July, 1879, and during the past year a large part of the work of mapping has been finished. Tracings of the maps of the survey have already been forwarded to the Chief of Engineers, and the final report on the same is hereto appended.

The special party (No. 6) making surveys and observations near Burlington, Iowa, completed their field work in the latter part of October, 1879. A report on this survey, together with maps and diagrams, was forwarded to Col. Z. B. Tower, president of the Board of Engineers on Low-Water Navigation of the Mississippi River. A copy of this report is hereto appended.

Many observations with current meters were taken by the Burlington party; but owing to the absence of Mr. G. A. Marr, the assistant in charge of these observations, for several months while in the employ of the Mississippi River Commission, the meter work has not been reduced or plotted. A report on this subject will be submitted as soon as practicable.

I take occasion at this time to refer to the report of the "Board of Engineers on Sheer-Booms," printed in H. Ex. Doc. No. 41, Forty-fourth Congress, second session. In this report the necessity and advisability of constructing sheer-booms at the various bridges were clearly shown, and plans for the same furnished for each bridge. The demand for sheer-booms for the protection and guidance of rafts becomes more urgent every day, and it should be given proper attention.

For the purpose of studying the river and its changes, determining where improvements are most needed, and noting the effect produced by works already constructed, numerous surveys and examinations have been made and will be continued during the present season.

Water-gauges are established at many points along the river between Saint Paul and Grafton, daily readings of which are kept on record,

and it is very desirable that these gauge records should be published in the newspapers for the benefit of navigation.

In accordance with instructions from the office of the Chief of Engineers, dated September 13, 1879, an examination was made of the harbor of Rock Island, the report on which, under date of November 5, 1879, will be found in H. Ex. Doc. No. 32, Forty-sixth Congress, second session.

Unless changes produced by the present extreme high stage of the river develop new and more troublesome obstructions requiring immediate attention, which cannot be known until the next low-water, work during the present fiscal year will be carried on at the following-named points:

1. Between Newport and Robinson's Island.
2. Island No. 20.
3. Head of Lake Pepin.
4. Between Wabasha and Alma.
5. Shore protection at Mount Vernon.
6. Rollingstone Slough.
7. Winona.
8. Queen's Bluff.
9. La Crosse.
10. Cassville Slough.
11. Bellevue.
12. Arnold's Bar.
13. Keithsburg.
14. Johnson's Island.
15. Shore protection at Oquawka.

The radical improvement of the Upper Mississippi River having been commenced, it is of great importance that it should be actively continued.

Large appropriations can be profitably expended and should be made in order that the benefits to be obtained may be secured as speedily as possible and that the ultimate cost may be diminished. I would accordingly ask for an appropriation of $500,000 for the fiscal year ending June 30, 1882.

SUMMARY OF EXPENDITURES FOR FISCAL YEAR ENDING JUNE 30, 1880.

At Hastings	$1,740 03
At Dibble's Point	2,372 02
At Smith's Bar	13,198 36
At Crat's Island	5,419 68
At Beef Slough	2,826 95
At Mount Vernon	14,328 74
At Rollingstone and Betsy Sloughs	7,726 02
At Winona	12,423 94
At La Crosse	4,717 33
At Cassville Slough	12,497 12
At Horse and Smith's Island	4,791 20
At Keithsburg	5,815 02
Maps and surveys	10,593 31
Allotted for "Adams's Flume"	20,000 00
Total expended	118,449 72

Money statement.

July 1, 1879, amount available	$142,049 77	
Amount appropriated by act approved June 14, 1880	150,000 00	
		$292,049 77
July 1, 1880, amount expended during fiscal year	118,235 54	
July 1, 1880, outstanding liabilities	214 18	
		118,449 72
July 1, 1880, amount available		173,600 05
Amount that can be profitably expended in fiscal year ending June 30, 1882.		500,000 00

REPORT OF J. L. GILLESPIE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 30, 1880.

SIR: I have the honor to submit the following report upon works constructed for the improvement of the Mississippi River from Saint Paul to Chimney Rock, during the fiscal year ending June 30, 1880, to which I have added the results of an examination of the river and existing works in my district made during the month of May, 1880.

EXAMINATION AT PIG'S EYE BAR.

The soundings were made at a stage of 7 feet above low-water of 1864, and show no material change since the last examination, except a slight filling at the upper and lower ends of the improved channel, which will undoubtedly cut out as the water falls. No examination was made at low-water last year, but pilots report not less than 4½ feet in the channel.

The left bank between dams 3 and 6 should be protected for a length of about 1,000 feet, but this is not immediately necessary.

EXAMINATION AT HEAD OF NEWPORT ISLAND.

The channel is straightening and improving slowly, and is sufficiently good so long as other bars in the vicinity remain in their present condition. The head of Newport Island should be protected, and the channel between Island No. 3 and the left bank closed. At the foot of Newport Island, and on the three crossings above Robinson's Island, there was less than 2 feet at low-water last season. These points will require first attention whenever the improvement of the river between Saint Paul and Hastings is continued.

SHORE PROTECTION AT HASTINGS, MINNESOTA.

This work was done under contract with Messrs. Winston Brothers of Minneapolis, Minn., dated June 4, 1879, Mr. F. A. Churchill, inspector. The shore protection was commenced at a point on the right bank, 3,600 feet below Hastings Railroad Bridge, opposite the dams built in 1878, and continued down stream 800 feet. The bank is about 12 feet above low water, the upper part being a hard clay, but underlaid by a stratum of sand near the low-water line, which cuts out and causes the upper stratum to cave off in large masses. The channel is working down this shore, and the protection should be extended down stream about 500 feet.

Materials used and cost of work.

Description.	Linear feet.	Stone, at 86 cents per cubic yard.	Brush, at 77 cents per cubic yard.	Amount.
Shore protection (sheet No. 6*)	800	1,231.7	580.8	$1,506 47
Superintendence and office expenses				233 56
Total				1,740 03

* The sheets referred to are the general maps of survey, Saint Paul, Minn., to Grafton, Ill.

EXAMINATION AT HASTINGS BAR.

The channel continues to widen somewhat, and there has been considerable filling between the spur dams. The boats have had no trouble here since the dams were built.

SHORE PROTECTION AT DIBBLE'S POINT.

This work was done under the same contract as that at Hastings. The left bank of the river opposite Prescott Island was protected for a distance of 1,250 feet up stream from the foot of the point.

The material of which the point is composed is a pure fine sand, easily cut away by the current, and the shore line had receded from 15 to 20 feet since the channel to the right of Prescott Island was closed last year.

Materials used and cost of work.

Description.	Linear feet.	Rock, at 86 cents per cubic yard.	Brush, at 77 cents per cubic yard.	Amount.
Shore protection (sheet No. 7)	1,250	1,575.6	907.3	$2,053 63
Superintendence and office expenses				318 39
Total				2,372 02

EXAMINATION OF HEAD OF PRESCOTT ISLAND.

Since last season the bar has cut out so that there is now a good 3-foot channel at low-water, which will probably improve as the water falls. This bar was composed largely of fine gravel, which resisted the scouring action of the current and rendered the deepening of the channel very slow; but of late it has improved rapidly, and no further trouble at this point is anticipated.

SMITH'S BAR.

This work was done under contract with S. J. Truax, of Hastings, Minn., dated August 29, 1879, Mr. H. N. Elmer, inspector. The river at this place was about 1,100 feet wide, forming a long shoal crossing from the left bank to the right bank, with about 2 feet in the channel at low-water. This has been the head of navigation for the larger boats during low-water for the past two seasons.

The channel was contracted to a width of 600 feet by five spur dams, three from the left and two from the right bank, and 1,000 feet of the right bank below the dams was protected by a revetment of brush and stone. The dams where less than 5 feet high were built with fascines 12 feet long, which effected a considerable saving of material. The examination in May showed a good channel of not less than 4½ feet at low-water.

Materials used and cost of work.

Description.	Linear feet.	Rock, at 89 cents per cubic yard.	Brush, at 79 cents per cubic yard.	Amount.
Dam No. 1 (sheet 8)	500	1,000.8	579.7	$1,348 67
Dam No. 2 (sheet 8)	150	604.2	645.0	1,047 29
Dam No. 3 (sheet 8)	350	999.8	948.2	1,638 90
Dam No. 4 (sheet 8)	300	1,058.9	1,007.0	1,737 95
Dam No. 5 (sheet 8)	525	1,526.5	999.0	2,147 80
Shore protection (sheet 8)	1,000	2,377.6	1,759.1	3,505 75
		7,567.8	5,938.0	11,426 36
Superintendence and office expenses				1,772 00
Total				13,198 36

SHORE PROTECTION OPPOSITE CRAT'S ISLAND.

The work at this place consisted in protecting the left bank of the river for a distance of 1,977 feet, divided as follows: 400 feet of low shore protection opposite the head of the island; then an interval of 432 feet unprotected, followed by 1,577 linear feet of protection carried to the top of the bank. Below this the bank juts out into the stream, deflecting the current to the right. It is proposed to allow this part of the bank to cut away until it is nearly straight, and then continue the protection down stream.

The bank is from 5 to 10 feet high, composed of a mixture of loam and fine sand, and had receded from 10 to 30 feet since the completion of the dam built in 1878. Materials were purchased in open market, and the work done by hired labor. Work was commenced August 27 and finished September 25.

Materials used and cost of work.

Description.	Linear feet.	Stone, at 73.8 cents per cubic yard.	Brush, at 49.3 cents per cubic yard.	Poles, at 4 cents each.	Amount.
Shore protection (sheet 14)	1,977	2,559.9	1,990.4	1,500	$2,928 33
Hire of boats and barges					962 00
Labor					802 69
					4,692 02
Superintendence and office expenses					727 66
Total					5,419 68

EXAMINATION OF CRAT'S ISLAND.

The high bar, which in 1878 was opposite dam No. 1, has moved down, and is now opposite dam No. 2, making the channel part of the dam, though deep, only about 300 feet wide. If this bar does not cut away as the water falls, it may be necessary to sink a line of mattresses between the dam and the bar to prevent further deepening and force a widening of the channel.

The tow-head between the head of Crat's Island and the left bank has disappeared, and the channel is cutting out down the left side of the island, which will probably render some protection at the upper end of the island necessary.

EXAMINATION OF BEEF SLOUGH BAR.

The channel above Tee-pe-ota Point has left the right bank and has been gradually working eastward for the past two years. The soundings show a good channel of sufficient width to the left of the high bar off the point. One or two spur dams from the right bank will maintain the channel in its present position, which is desirable.

The bar west of Island 31 will probably move down and gradually close the present channel, throwing the water between Islands 33 and 34. Whenever this takes place the projected dam from the left bank to Island 34 should be built.

DAM AT FOOT OF BEEF SLOUGH.

Work was commenced here June 1, 1880, and the shore protections and bottom layer of dam No. 1, from the left bank to Island 36, were put in. Owing to the present high stage of water it was necessary to suspend the work, which will be resumed as soon as the stage of water permits. The work was done by hired labor, material being purchased in open market.

Materials used and cost of work.

Description.	Linear feet.	Rock, cubic yards.	Brush, cubic yards.	Poles, number.	Amount.
Dam No. 1 (sheet 14)	1,200	682	780.11	1,284	$927 04
Hire of boat and barges					514 95
Labor					770 58
Tools, &c					234 89
					2,447 46
Superintendence and office expenses					379 49
Total					2,826 95

MOUNT VERNON BAR.

This work was done under contract with Messrs. Jenkins & Van Gorder, of Winona, Minn., dated September 3, 1879, Mr. J. C. McElherne, inspector.

Mount Vernon Bar is formed by the junction of Pomme de Terre Chute with the main channel of the river at the foot of Island 48, and has been a serious obstruction to navigation for many years.

At low-water of 1879 there was a narrow and crooked channel of about 3 feet depth across the bar.

The plan of improvement adopted was to contract the channel across the bar to a width of 900 feet, by spur-dams, and also close the channel to the left of Island 50 and the tow-head below. Work was commenced September 23, and completed December 2, 1879.

Materials used and cost of work.

Description.	Linear feet.	Stone, at $1.23 per cubic yard.	Brush, at 58 cents per cubic yard.	Amount.
Dam No. 1 (sheet 16)	300	1,500.0	1,152.5	$2,455 82
Dam No. 2 (sheet 16)	620	1,191.2	1,431.0	2,223 60
Dam No. 3 (sheet 16)	1,400	2,012.8	3,170.0	4,155 84
Dam No. 4 (sheet 16)	650	1,198.4	1,539.1	2,289 74
Dam No. 6 (sheet 16)	200	331.1	281.0	556 19
Shore protection Island 50 (sheet 16)	250	438.44	343.52	721 35
				12,402 54
Superintendence and office expenses				1,926 20
Total				14,328 74

EXAMINATION AT MOUNT VERNON BAR.

The soundings show a channel of 4½ feet at low-water, not less than 300 feet wide, which will doubtless improve as the river falls. There is no probability of any further trouble at this point.

Very respectfully, your obedient servant,

J. L. GILLESPIE,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

ROCK ISLAND, ILL., *June* 30, 1880.

CAPTAIN: I have the honor to submit my annual report of work done on the improvement on the Upper Mississippi River, between Rock Island, Ill., and Chimney Rock Bar, Minnesota, for the fiscal year ending June 30, 1880, as follows:

GENERAL REMARKS.

The work done last season was similar in character to that of the preceding year. The same forms of dams and shore protections were used, but with the difference that it was endeavored to use a larger proportion of brush in the dams, and on the shore protections a smaller proportion of rock; both of which attempts have so far resulted in a reduction of cost, without any apparent want of stability in the structures themselves.

The supply of brush, however, in the vicinity of all the larger works on the Upper Mississippi River is becoming scarce, and it seems as if some steps should be taken to secure a future supply, if the works are to go on, and to economize brush in the constructions projected. The first consideration would necessitate the planting of sand-bars; the latter the adoption of a form of dam consisting mostly of rock or dredged material.

The past season was a trying one for steamboats, and has, I think, proved conclusively the beneficial effects of works of improvement already completed. The constructions of 1878 have in every case proved successful in giving a good channel where they had been advanced to anything like a completed state.

I think an effort should be made this year to test the usefulness of sand-bar planting, and the experiment should be made in the fall, after the water becomes low. Should the experiment prove a failure, it should be tried again next spring, before the June rise. Very few of the willows put into our dams or shore protections have taken root, from the fact that they were usually cut in the hot months.

ROLLINGSTONE BAR.

The work on this bar, and also on that at the foot of Betsy Slough, was done under a contract with Mr. Jacob Richtmann, of Fountain City, Wis.; inspector, Mr. James P. Allen.

The closing dam in Rollingstone Bend, from Island 57 to the Minnesota shore, was examined early in the season and no settling of consequence was detected. Soundings below the gap 200 feet wide, left for the passage of rafts, developed a great amount of scour, a hole having been excavated which measured 54 feet deep at low water. From this point the bottom rose gradually to the foot of the dam, which latter seems to have suffered no bad effects.

It was impossible to place any large amount of rock in the gap without interfering with the passage of rafts. There is no doubt but that this gap wastes a vast amount of water needed in the main channel to the left of Island 57. Either the gap must be closed and the dam raised or dam No. 1 extended and raised so as to divert the water at that point. The latter plan will conflict less with large private interests, and I would recommend its adoption.

Dam No. 2 was built from the head of Island 57 out to the proposed channel line. This was to stop a great escape of water between the bar and the head of Island 57, and caused it to flow around the end of the dam, and assist in scouring out the bad crossing opposite the island. (See map, Report Chief of Engineers, 1879.) In the lowest place this dam was built to 2 feet above low-water, the portion on the sand-bar being some 2 feet higher or 5 feet above low-water.

Dam No. 9 is a submerged dam built to prevent the water cutting any deeper along the face of the bank opposite Island 58; 300 feet of shore protection was built at the junction of the dam with the shore, and 800 feet more will be needed, as this bank is cutting rapidly. There is nowhere less than 4½ feet of water over Dam 9 at lowest stage.

An examination made May 17, 1880, shows that there is a considerable widening of the 3-foot channel opposite Island 57. The bar has been forced down upon the head of dam No. 6, and the channel-way contracted to a width of only 250 feet. At a lower stage than that prevailing at the date of the examination, this width will no doubt be increased.

A dam should be built from the left bank to contract the water-way across the bar opposite Island 57.

All the works recommended above should be put in during the season of 1880.

BETSY SLOUGH.

The dams and shore protections built in 1878 have stood well, and have secured a channel across this very bad bar, which has never since the completion of the dams had less than a 4½-foot channel. During the past season 1,024 feet of shore protection has been put in on the left bank of Betsy Slough—included in last annual report—and 1,000 feet on the right bank of the river, below the foot of Island 63, built after June 30. The bank below both these pieces of riprap will need at no distant day some further protection. The two sloughs opposite Wilds, 1 mile below Betsy Slough, should be closed, as the river shows a tendency to draw in that way.

Detailed cost of Rollingstone and Betsy Slough work.

Description.	Linear feet.	Rock, at $1.10 per cubic yard.	Brush, at 60 cents per cubic yard.	Amount.
		Cu. yds.	*Cu. yds.*	
Dam 2 (sheet No. 17)	668	1,667.5	903.0	$2,376 47
Dam 9 (sheet No. 17)	196	932.6	551.1	1,356 52
Shore protection No. 3 (sheet No. 17)	1,000	2,206.3	881.5	2,955 83
		4,806.4	2,335.6	6,688 82
Superintendence and office expenses				1,037 20
Total expended				7,726 02

WINONA.

This work was begun September 16, under a contract with Jenkins & Van Gorder, of Winona, Minn. The inspector was Mr. James P. Allen. Two dams were built, as shown on the accompanying map, and two pieces of shore protection. It was found impossible to build the works as originally planned, as it would have interfered too much with the navigation. While construction was in progress, September 24, there were nine steamers held there trying to cross the bar.

Dam No. 16 was built to a height of 4 feet above low-water. The end abutting on Island 70 will probably settle somewhat, the sand-bar on that side of the slough being extremely soft and easily disturbed. The dam extends from Island 70 to Island 71, and is 710 feet long. It stops a slough which diverted a large portion of the low-water flow from the main river.

Dam No. 20 extends from Island 71 to Island 72, and closes a similar gap, dry at low-water. This dam consists of one layer of rock and brush only. The shore protections on Island 71, and opposite Argo Island, were, like those at Betsy Slough, built lighter than those put in in 1878, and appear to stand equally well.

An examination made May 4, 1880, at a stage of 8.1 feet above low-water, shows that the channel has changed somewhat since 1878, being closer to the head of Island 72. The 3-foot contours give a width of channel not less than 400 feet on the crossing. It will be necessary to contract the width of the channel opposite Island 71 by a spur or spurs from the right bank, as the river is here very flat, and the water is wasted over a large area.

There should also be a spur from Island 72, and some shore protection on the head of Island 72. A small slough back of Island 70 should also be closed, as a large amount of water is wasted through it, and the width appears to be increasing.

Detailed cost of Winona works.

Description.	Linear feet.	Rock, at \$1.17 per cubic yard.	Brush, at 53 cents per cubic yard.	Amount.
		Cubic yds.	*Cubic yds.*	
Shore protection No. 13 (sheet 18)	1,185	1,622.6	1,027.0	\$2,442 75
Dam No. 16 (sheet No. 18)	710	2,295.1	1,765.6	3,621 02
Shore protection (sheet 18)	1,365	2,189.4	1,736.1	3,481 73
Dam No. 20 (sheet 18)	395	812.1	491.1	1,210 44
		6,919.2	5,019.8	10,755 94
Superintendence and office expenses				1,668 00
Total expended				12,423 94

QUEEN'S BLUFF.

No work was done at this place last season, though authority was granted for some riprap opposite the dams, other places appearing to need the expenditure more. This shore protection should be put in soon. The result of the works at Queen's Bluff, put in in 1878, has been very gratifying, no detention to steamboats having occurred during the past season even at the lowest stage of water. No examination was made at this bar during the past spring, but it is believed that the low-water season will show the continuance of the good results attained last year.

LA CROSSE.

Late in the season the river above La Crosse showed a strong tendency to cut in behind Island 105, owing to a straightening of the main channel, which threw the current directly on the head of the island.

A low dam was built from Island 105 to the left bank, and 375 feet of riprap put in at the head of the island.

It was intended to put in some shore protection on the shore of Barron Island, opposite and below the head of Island 105, which needs it very much, but the cold weather drove the working parties from the field. The work was done under an informal contract with P. S. Davidson, of La Crosse. Mr. C. M. Bennett was the inspector.

The dams at Island 104 and Island 106 cannot be considered as more than partially improving this part of the river. The bar above the city was in a very bad condition last season and caused much delay and trouble to steamers and rafts.

The water flows over this bar in a thin sheet, and should be concentrated so as to give greater depth. This could be accomplished by building a training wall down stream from a point at the junction of the Black and Mississippi rivers, and a short spur from the shore of Island 106. This work and the riprap on Island 106, above referred to, are very important. The cutting away of the shore of Island 106 is progressing very rapidly and contributing great masses of material to the bar below. There is a small slough which enters Black River opposite the elevator wharf and has caused the formation of a sand-bar, which greatly interferes with the operations of steamers and rafts. This slough should be closed.

Detailed cost of La Crosse work.

Description.	Linear feet.	Rock, at $1.23 per cubic yard.	Brush, at 75 cents per cubic yard.	Amount.
		Cubic yds.	*Cubic yds.*	
Closing dam No. 4 (sheet No. 21)	350	1,293.0	764.00	$2,163 39
Shore protection No. 1 (sheet No. 21)	375	1,276.1	467.95	1,920 58
Total		2,569.1	1,231.95	4,083 97
Superintendence and office expenses				633 36
Total expended				4,717 33

FOOT OF CASSVILLE SLOUGH.

Work could not be begun until late in the season owing to a combination of circumstances. No contractor could be found willing to undertake the furnishing of brush and rock so near the cold weather season, so all the work was done by hired labor. The work was somewhat delayed by rain and wind, the latter making the handling of steamer and barges difficult. Finally, the close of navigation drove the working party in before the work was completed.

The closing dam from Island 192 to the main shore was finished, also the riprap at the head of Island 192. Eight hundred and fifty feet of riprap on the right bank opposite the head of Island 192 was completed to a height of 4 feet above low-water. An examination made April 27, 1880, shows a great improvement in the condition of this bar due to the action of the dam at Island 192.

There is a wide 3-foot channel and but slight interruption to the 4½-foot channel. The water shows a tendency to follow the shore of Island 192, and should be intercepted by a low spur. The shore near the foot of 12-mile Island, opposite 192, forming the right bank of the chute, should be further riprapped, as it is of very sandy material and washes rapidly.

This bar gave great trouble to both steamers and rafts during the low-water of September and October, 1878. Some of the raft-boats could not cross at all and had to lie below the bar, waiting for their rafts to be sent down to them by a lighter boat.

The bar has been for many years one of the worst obstructions on the Upper Mississippi River.

Detailed cost of Cassville work.

Cost of labor	$7,108 90
Hire of steamer and use of steam-launch	1,618 20
Hire of barges	1,060 65
Purchase of tents and plant	405 57
Cost of lath yarn, 2,180 pounds	192 50
Purchase of powder (110 pounds still on hand)	368 40
Quarry and brush royalties	65 00
Superintendence and traveling expenses	1,677 90
Total cost	12,497 12

Summary.

Description.	Linear feet.	Poles.	Rock.	Brush.
			Cubic yds.	*Cubic yds.*
Closing dam No. 1 (sheet 33)	520	1,811	3,098.25	2,348.50
Shore protection No. 1 (sheet 33)	423	784	1,094.00	842.00
Shore protection No. 2 (sheet 33)	850	450	879.00	779.50
Received at works and not put in	....	430	125.00	556.00
Totals	....	3,475	5,196.25	4,426.00

Summary of cost.

Description.	Cost per cubic yard.	Total.
Value of material on hand	....	$204 87
9,040.75 cubic yards material put in work	$1 17½	10,614 35
Superintendence and traveling expenses	....	1,677 90
Total cost	....	12,497 12

BELLEVUE BAR.

No work has been done at this place since 1878, when the dam was put in at the head of Island 248.

Two examinations were made during the present fiscal year, one in August, 1879, at low-water, and one April, 1880, at a high stage. Both show a marked tendency of the water to form a new channel close to the right bank of the river. This will be a great improvement if it can be secured. A small amount of dredging towards the lower end of the bar would perhaps determine the channel in the desired position, and I recommend that the attempt be made. The channel once secured in this place will probably be permanent, or at least will allow of its being made so at a small proportionate cost. Bellevue Bar continued to give trouble last year, and many rafts and steamers were delayed there. The dam at the head of Island 248 has stood well, but only was built 1½ foot above water and should be raised at least 2 feet.

HARBOR OF ROCK ISLAND, ILLINOIS.

A survey and estimate was made under your orders September 17, 1879, showing the condition and cost of removing of a sand-bar which envelops the river front of Rock Island, and interferes greatly with navigation. A small amount of dredging would afford great relief to the steamers landing here for freight and coal, Rock Island being one of the principal coaling stations on the Upper Mississippi River. (See your letter to Chief of Engineers dated November 5, 1879, forming part of H. Ex. Doc. No. 32, Forty-sixth Congress, second session.)

ARNOLD'S BAR.

Great trouble and delay were experienced last season at Arnold's Bar. The river splits on Island 259 into two channels, and has for several years been in very bad condition at low-water. A dam should be built closing one or the other of these channels, the one to be closed being determined by surveys later in the season. The head of Island 259 should also be protected by riprap, and some riprap put in on the shore below Island 259 if the left arm of the river is closed.

SAMPLES OF MATERIALS.

Samples of sand, clay, and mud were collected at various places during the past season. In obedience to your orders I append the following table of specific gravities and weights per cubic foot. The samples of sand taken from different bars vary little in appearance, nearly all the bars containing all the different grades in varying proportions and positions.

The samples of materials from Galena River were taken with a dredge, and the weight per cubic foot determined by actual measurement in a box 1 cubic foot in dimension. The specific gravity in this case has been determined from the weight per cubic foot, water at maximum density being the standard.

In all the samples except those, taken from Galena River, the sand was well shaken in the bottle until it would compact no more. The weights and specific gravities of the wet sand refer to sand perfectly wet, the excess of water being poured off. Wet sand taken from a dredge would be lighter as it would contain less water. The ratio of absorption given in the table is understood to be the difference of weight between the same sample wet and dry, divided by the weight of a volume of water equal to the volume of sand.

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Capt. ALEXANDER MACKENZIE,
Corps of Engineers, U. S. A.

Table of specific gravities, &c.

Locality.	Number of sample.	Specific gravity.	Weight in pounds per cubic foot.	Rates of absorption.	Remarks.
Prescott Bar	7	1.8072	112.81	0.34894	Very fine sand; dry.
	7	2.1547	134.51	....	Very fine sand; wet.
	5	1.7875	111.58	0.34992	Medium, coarse and fine mixed; dry.
	5	2.1359	133.34	....	Do.
	10	1.8917	118.28	0.16146	Gravel and sand mixed; dry.
	10	2.0519	128.15	....	Gravel and sand mixed; wet.
Smith's Bar	10	1.6683	104.25	0.26963	Very fine sand; dry.
	10	1.9386	121.05	....	Very fine sand; wet.
	15	1.8106	112.98	0.35880	Medium, coarse and fine mixed; dry.
	15	2.1630	135.33	....	Medium, coarse and fine mixed; wet.
	4	1.8820	112.08	0.13313	Gravel and fine sand mixed; dry.
	4	1.9407	121.15	....	Gravel and fine sand mixed; wet.
Mount Vernon	15	1.7272	107.90	0.36838	Very fine sand; dry.
	15	2.0958	130.80	....	Very fine sand; wet.
	16	1.8824	117.51	0.31456	Medium and fine sand mixed; dry.
	16	2.1956	137.06	....	Medium and fine sand mixed; wet.
	10	1.8738	116.97	0.11341	Fine gravel with a little sand; dry.
	10	1.9867	124.02	....	Fine gravel with a little sand; wet.
Dubuque Bar	3	1.7682	110.38	0.32369	Very fine sand, impure, lower edge of bar dry.
	3	2.0905	130.51	....	Very fine sand, impure, lower edge of bar; wet.
	2	1.8557	115.84	0.31431	Fine sand, opposite Waple's Cut; dry.
	2	2.1688	135.39	....	Fine sand, opposite Waple's Cut; wet.
	1	1.7882	111.63	0.32183	Pure sand, outer edge of bar; dry.
	1	2.1150	132.03	....	Pure sand, outer edge of bar; wet.
Bellevue Bar	4	1.7137	106.98	0.34436	Very fine sand; dry.
	4	2.0566	128.38	....	Very fine sand; wet.
	3	1.6819	104.99	0.31636	Coarse sand; dry.
	3	1.9969	124.66	....	Coarse sand; wet.
	6	2.2378	139.70	0.17733	Coarse gravel and a little sand; dry.
	6	2.3635	147.55	....	Coarse gravel and a little sand; wet.
Galena River	......	1.8738	117.00	....	Medium sand, from bar foot Harris's Slough; wet.
	......	1.9063	119.00	....	Sand, slightly impure, surface of bar; wet.
	......	1.8262	114.00	....	Mud, same locality as above.
	......	1.5539	97.00	....	Mud, very soft, opposite Station 22.
	......	1.6180	101.00	....	Clay at Spratt's Lake.
	......	1.9255	123.00	....	Sand, very fine and impure, above Spratt's Lake; wet.
	......	1.9063	119.00	....	Clay and mud, a little sandy; wet.

REPORT OF MR. E. F. HOFFMANN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 30, 1880.

CAPTAIN: I have the honor to submit my annual report in reference to certain works for improving navigation of the Mississippi River from Rock Island to Des Moines Rapids.

WORK NEAR HORSE ISLAND.

It was decided to improve the channel of the river near Horse Island, about 4 miles below Rock Island, by removing certain patches of rock. Two trials were made by a dredge, which showed the necessity of first chiseling the rock. Messrs. Whitney & Son obtained the contract for removing this rock, for which they were paid $2.50 per yard. The horizontal stratification of the rock made it necessary to break 2½ feet of rock, and the estimated amounts of these patches were very much overrun, so that only a part of the improvement could be effected with the funds available. From August 26 to October 16, 1879, 1,583.79 cubic yards of rock were removed, leaving 250 cubic yards chiseled but not removed. Dredging was resumed March 31, but only 75.7 cubic yards of rock were removed, work being stopped by high stage of water. The total quantity of rock removed at Horse Island is, therefore, 1,659.17 cubic yards, and the amount of money paid for its removal is $4,147.92.

REMOVAL OF OBSTRUCTIONS AT SMITH'S ISLAND.

It having been reported that bowlders were to be found in the middle of the channel near Smith's Island, about 8 miles below Rock Island, with but 2 feet of water over them at low-water, an examination was made, and the steam-drill was taken down to the locality. The so-called bowlders proved to be heavy building stone unloaded from a flat-boat caught in the ice in this vicinity in 1866. By constructing a derrick upon the steam-drill scow, and using the powerful capstan engine of the boat, 13 heavy building stones were taken from the river and deposited on the Iowa shore. These stones averaged from 1½ to 2 cubic yards each in contents. Lying closely together they might easily have been taken for bowlders. This work was finished on November 14.

DREDGING AT KEITHSBURG, ILLINOIS.

The river at this place is very wide, and at a low stage of water very shallow, with a bottom which has always been called rock. On the 3d of November a chisel-boat was placed at the crossing and commenced work. A few days later the dredge was towed into position. It soon became evident that the dredge could execute the work without the assistance of the chisel-boat, and it was therefore withdrawn. A careful observation in reference to the composition of the material dredged up classifies the different parts of the conglomerate as follows:

60 per cent. is a hard black clay.
30 per cent. are bowlders of sienite, granite, porphyry, &c.
5 per cent. is a coarse gravel.
5 per cent. is a coarse sand.

The work was vigorously pushed by Messrs. Whitney & Son, the contractors, until the inclement weather forced the withdrawal of the dredge November 30. The monthly estimate showed during 26 actual working days a daily excavation of about 206 cubic yards, or a total of 5,355.1 cubic yards. Under the first supposition that the material at this bar consisted of solid rock, which could only be excavated by chisel-boat and dredge, the price per cubic yard was to be $2 for work done by the chisel-boat, and $1 for work accomplished by the dredge, but when the nature of the material was fully developed, the price was changed to 60 cents per cubic yard.

On March 19, 1880, work of excavation was resumed and continued until March 30. During this time 2,272.66 cubic yards of material were removed. The estimated amount of dredging for improving the crossing at Keithsburg is 29,057 cubic yards, and the amount of material removed was 7,627.76 cubic yards, leaving 21,430 cubic yards yet to be dredged, as is shown in the sketch accompanying this report.

An appropriation of $20,000 is necessary to make the work commenced useful for navigation. The money so far expended for the removal of the 7,627.76 cubic yards excavated is $5,034.32.

All of which is most respectfully submitted.

E. F. HOFFMANN,
Assistant Engineer.

Capt. ALEXANDER MACKENZIE,
Corps of Engineers, U. S. A.

Abstract of all proposals received and opened this 27th day of August, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. A., for building dams and shore protections of brush and stone at Smith's Bar, 5 miles below Prescott, Wis.

Number.	Names and residences of bidders.	7,000 cubic yards stone.		6,500 cubic yards brush.		Aggregate
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	E. E. Heermann, Reed's Landing	$1 85	$12,950	$1 50	$9,750	$22,700
2	P. S. Davidson, La Crosse, Wis	1 10	7,700	80	5,200	12,900
3	John Gage, Wabasha, Minn	1 24	8,680	79	5,135	13,815
4	Winston Bros., Minneapolis, Minn	1 15	8,050	88	5,720	13,770
5	Sid. J. Truax, Hastings, Minn	89	6,230	79	5,135	11,365

Abstract of all proposals received and opened this 27th day of August, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. A., for building dams and shore protections of brush and stone at Mount Vernon Bars, 2 miles below Minnieska, Minn.

Number.	Names and residences of bidders.	10,000 cubic yards stone.		9,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	E. E. Heermann, Reed's Landing, Minn	$1 95	$19,500	$1 50	$13,500	$33,000
2	P. S. Davidson, La Crosse, Wis	1 20	12,000	80	7,200	19,200
3	J. H. Jenkins and S. D. Van Gorder, Winona, Minn	1 23	12,300	53	4,770	17,070
4	Robert M. Mooer and L. Rossiter, La Crosse, Wis	1 50	15,000	*50	4,500	19,500
5	Jacob Richtman, Fountain City, Wis	1 40	14,000	80	7,200	21,200

Abstract of all proposals received and opened this 27th day of August, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. A., for building dams and shore protections of brush and stone at bar 1 mile above Winona, Minn.

Number.	Names and residences of bidders.	10,000 cubic yards stone.		9,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	P. S. Davidson, La Crosse, Wis	$1 20	$12,000	$0 80	$7,200	$19,200
2	J. H. Jenkins and S. D. Van Gorder, Winona, Minn	1 17	11,700	53	4,770	16,470
3	Robert M. Mooer and L. Rossiter, La Crosse, Wis	1 50	15,000	50	4,500	19,500
4	Jacob Richtman, Fountain City, Wis	1 20	12,000	80	7,200	19,200

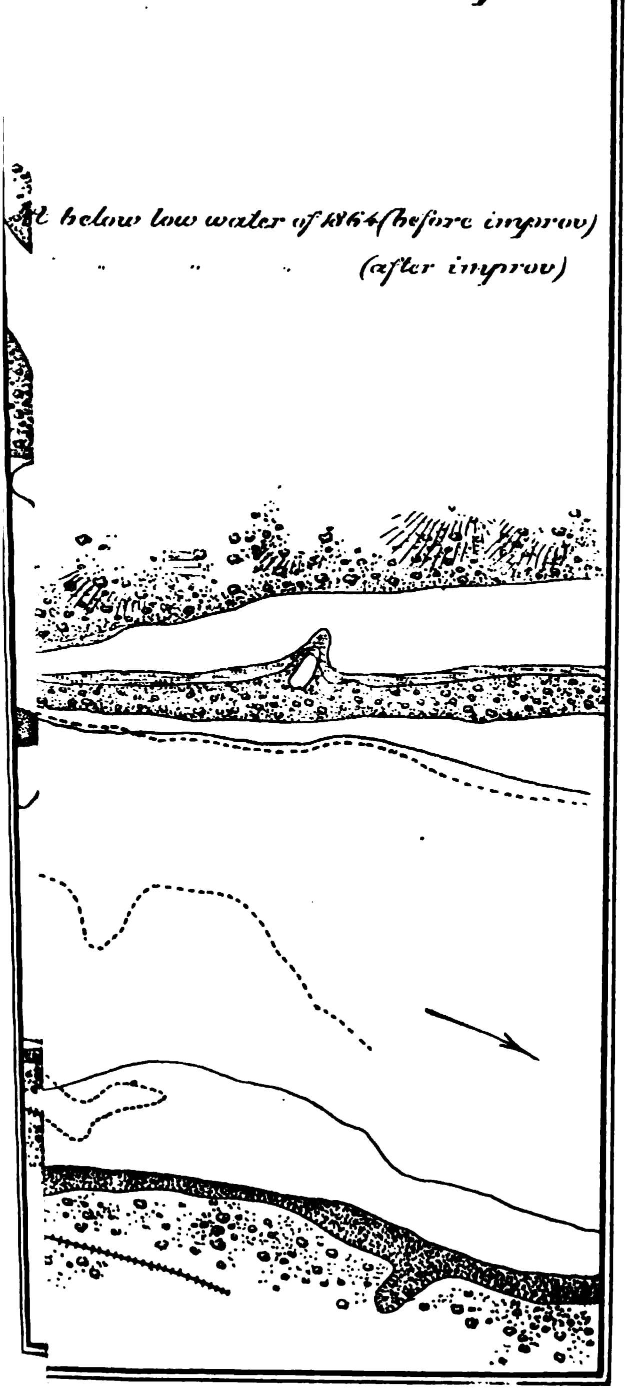
S 3.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM DES MOINES RAPIDS TO MOUTH OF THE ILLINOIS RIVER.

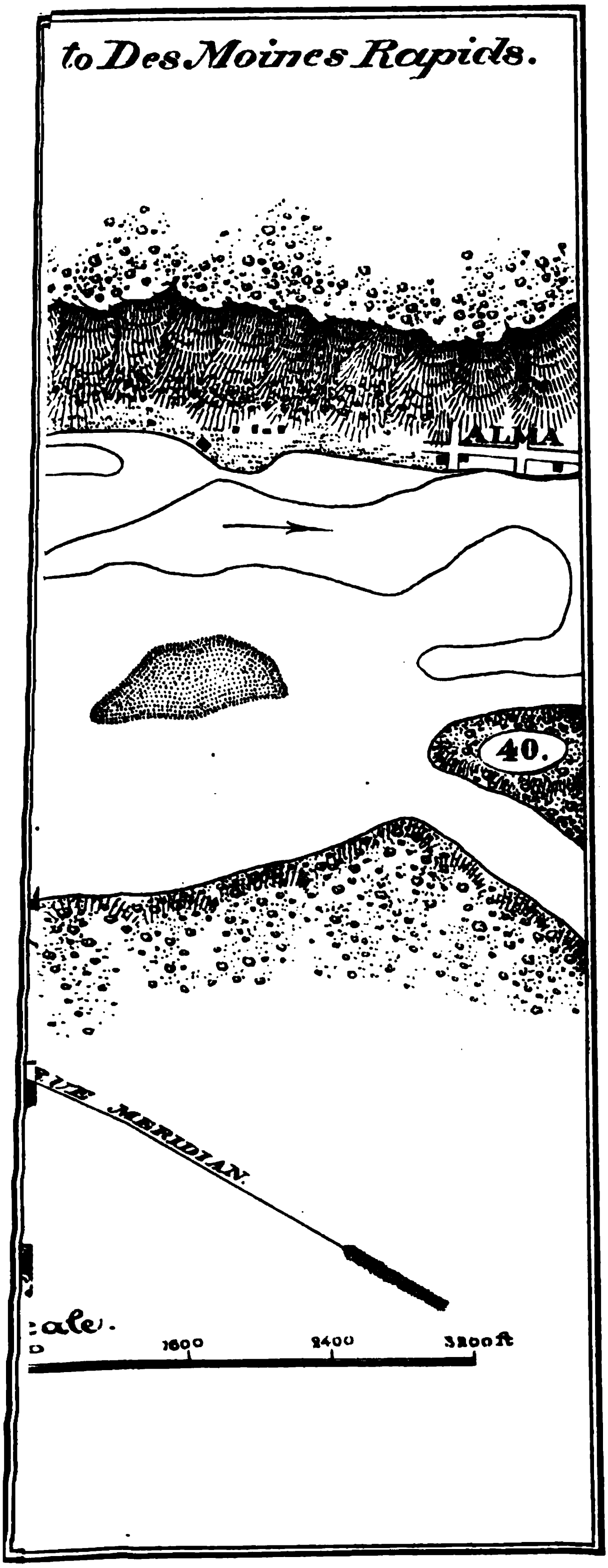
The works under this head of appropriation were in local charge of Capt. B. D. Greene, Corps of Engineers, until January 1, 1880, at which time he was transferred to Detroit. From his reports and memoranda many of the following details were gathered. He took personal charge of operations in the field, and to his intelligent and zealous labors is due in great part the successful management of the work.

1

'Paul to Des Moines Rapids.



St Paul to Des Moines Rapids.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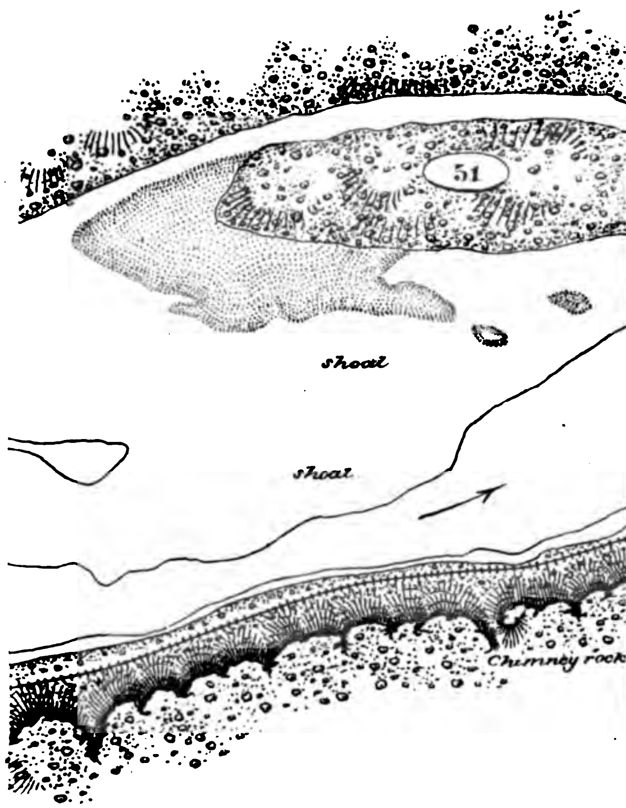
St Paul to Des Moines Rapids.



ft at low water of 1864. Survey of 1878

Scale.

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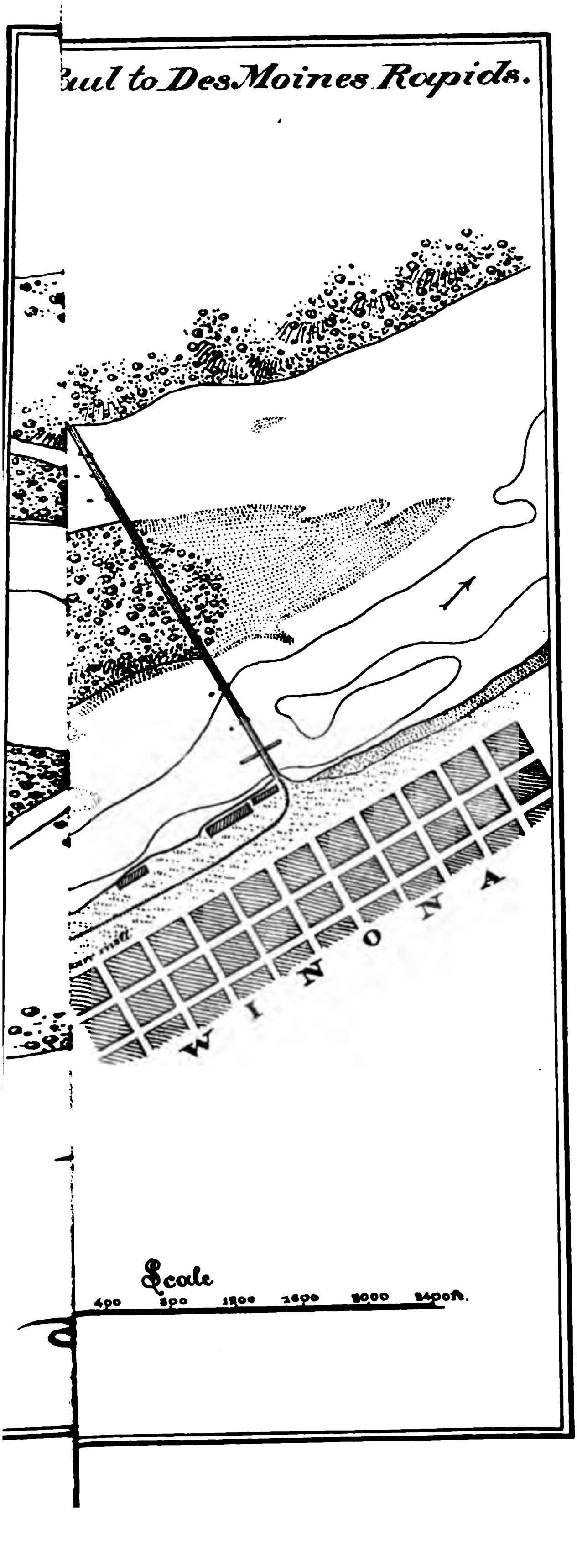
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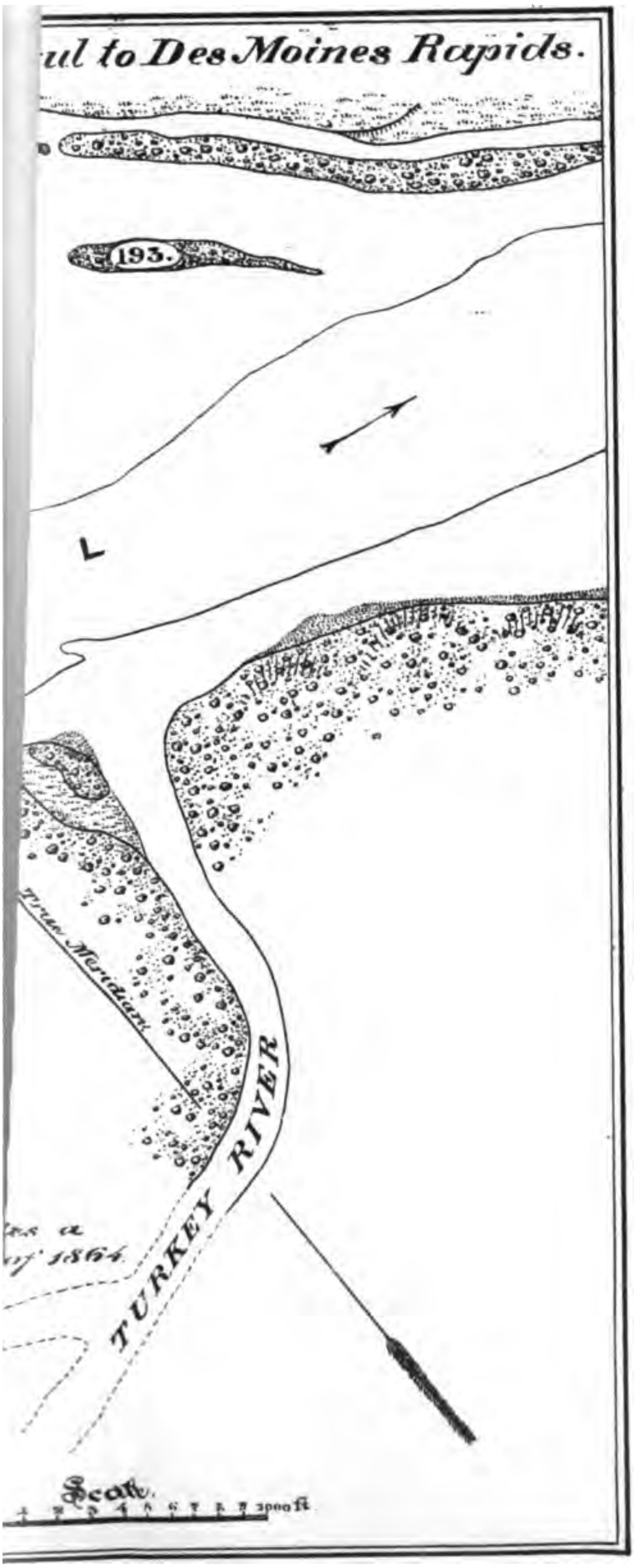
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I.—CANTON, MISSOURI.

The improvement of the river in this vicinity, and for a stretch of river 17 miles in length, extending from Canton to Quincy, embracing Wyaconda Bar and several other shallow crossings, was selected as one of the points of operations under the appropriation for fiscal year ending June 30, 1880. For nearly the whole distance the river was divided into two channels, the one to the west being the main channel, and the one to the east called Canton Chute. This latter carried about one-fourth of the total volume of water in the river.

The work proposed by Major Farquhar in his project of April 8, 1879, was the closing of Canton Chute near its head by a dam of brush and stone; the closing of several smaller lateral chutes below, which diverted considerable water from the main channel; and a spur dam from above the head of Canton Chute, with a view to shifting the channel to the Canton shore, and improving the steamboat landings at that place. It was thought that the increased volume of water thus turned into the main channel would materially benefit the stretch of river above mentioned, and especially improve Wyaconda Bar. The above indicated project was approved by the Chief of Engineers, under date of May 12, 1879.

Owing to the small amount of money allotted for this locality, it was decided to first construct only the Canton and Smoot Chute Dams, and to protect from abrasion the head of Island No. 416. The work was advertised, and the contract awarded to S. S. Sample, of Keokuk, Iowa, who began work September 18, 1879, and finished November 25.

Canton Chute Dam (No. 1, sheet 66).—This closing dam was located about 700 feet below the head of Island No. 416, is 1,095 feet long, with shore protection on the island end 200 feet in length, and on the Illinois shore 80 feet. The crest of the dam was raised to a height of 4 feet above low-water. About 150 feet of the dam, being built on a quicksand bottom, settled about 3 feet; and this gap was afterwards filled with rock and gravel. Captain Greene, in speaking of the Canton Chute Dam, says:

> Near one end of the dam there was some trouble from settling, for a distance of 150 feet or more. This was stopped by backing up with gravel for a distance of 8 or 10 feet. The bar from which this gravel was taken is, so far as I know, the only bed of pure gravel upon this section of the riyer. It is situated just at the entrance to Canton Chute, extending out from the main shore, and is of very considerable extent. This gravel will be valuable in works of improvement, and perhaps still more so if placed on the country roads. Other gravel bars in this vicinity contain an excess of disintegrated limestone and flint.

Smoot Chute Dam (No. 2, sheet 66).—This dam is 370 feet long, with 200 feet shore protection at each end, and was built across the lateral chute between Islands No. 416 and 418. It was brought up to a height of 2 feet above low-water of 1864.

Shore protection at head of Island No. 416 (No. 1, sheet 66).—This is about 1,000 feet in length, extending 200 feet down the chute, and 800 feet along the western side of the island, with an average width of 35 feet.

Summary of work at Canton, Mo., for fiscal year ending June 30, 1880.

Description.	Linear feet.	Rock, at $1.09 per cubic yard.	Brush, at $0.77 per cubic yard.	Gravel, at $1.09 per cubic yard.	Amount.
		Cubic yds.	*Cubic yds.*	*Cubic yds.*	
Canton chute dam	1,095	3,422.61	2,278.41	256.43	$5,764 52
Smoot chute dam	370	1,345.88	829.91		2,105 49
Shore protection	1,000	1,268.24	1,026.48		2,172 77
Total		6,036.23	4,134.80	256.43	10,042 78
Superintendence, office expenses, &c					696 60
Total expended					10,739 38

Mr. W. A. Thompson, inspector at Canton, deserves credit for the able and zealous performance of his duties.

II.—HANNIBAL, MISSOURI.

A small amount of dredging was done here by special direction of the Secretary of War. This furnished temporary relief just at the steamboat landing and the trouble will recur until radical changes are made in the river in this vicinity. A report on this subject was submitted by me January 17, 1880, and is printed in Miscellaneous Document No. 24, Forty-sixth Congress, second session.

Summary of work at Hannibal, Mo., for fiscal year ending June 30, 1880.

Dredging 3,845.85 cubic yards mud and sand, at 20 cents	$769 17
Superintendence, office expenses, &c	53 34
	822 51

III.—GILBERT'S ISLAND.

The works proposed at this place were to close Gilbert's Chute, to protect the Illinois shore, and to build several spur dams in the vicinity of Gilbert's Island to rectify the channel of the river. This project of Major Farquhar, Corps of Engineers, was submitted through the Chief of Engineers to the Board of Engineers on the low-water navigation of the Mississippi River, and approved by them, as follows:

BOARD ROOM, ENGINEER OFFICE,
Saint Louis, Mo., November 15, 1878.

GENERAL: * * * The Board approves of the building of the closing dam in Gilbert's Chute, the spur dam from right bank at head of chute, the spur on sand bar from left bank above Gilbert's Island, and a shore protection on the Illinois shore wherever it may be found necessary. The other works at and below the head of the island to be built when a necessity for them is shown.

Very respectfully, your obedient servant,

J. G. BARNARD,
Colonel of Engineers and Bvt. Maj. Gen.,
President of the Board.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

The above finding of the Board was approved by the Chief of Engineers under date of November 26, 1878. By letter from the Chief of Engineers dated August 15, 1879, I was authorized to make such changes

in the conduct of the work as experience should dictate, it being impossible to devise plans for the improvement of any considerable stretch of river which could be rigidly carried out, I was also authorized to employ dredging as an auxiliary.

The contract for the works at Gilbert's Island had been awarded to W. A. McConnell, of Quincy, Ill., but owing to his failure to make satisfactory progress, it was taken from him and given to his sureties, who carried on the work until the latter part of September, when, the approximate quantities having been furnished, the contract was closed. Much annoyance and delay resulted from the failure of the contractor to perform his contract, and subsequently from the inefficiency and inexperience of the sureties. Early in October the work was taken in hand by the government and prosecuted by hired labor to the close of the season.

Gilbert's Chute Dam (No. 6, sheet 73).—This is 1,775 feet in length and located about 2,500 feet below head of Gilbert's Island, with shore protections on each end. The greatest depth of water on the line of the dam was 7 feet below low-water of 1864, and the average depth 4.27 feet. The construction was the same as heretofore adopted. As originally designed the crest of this dam was built to 1 foot below low-water of 1864 in the center, from whence it gradually rose to 2 feet above low-water at Missouri shore and 3 feet above at the island shore, and it was completed on this plan on June 17, 1879. Subsequently it was decided to raise it, and in September a further quantity of rock and gravel was placed on it bringing the elevation throughout to a height of 2½ feet above low-water.

Dam No. 5 (sheet 72).—A wing dam was commenced beginning at the gravel point just above head of Gilbert's Island on Missouri shore and extending out into the river for the purpose of turning the current down the Cincinnati side. After a short time, however, work on this dam was stopped, other points appearing to require more immediate attention.

Illinois shore protection (No. 1, sheet 72, Nos. 2 and 3, sheet 73).—That part of the Illinois shore requiring protection extends from a point opposite head of Gilbert's Island to dam No. 3, a distance of 13,000 feet. A portion of this work was done in May and June, 1879, some 1,050 feet of bank being protected at that time. Later in the season about 9,000 additional feet of shore protection were built at such places as it was deemed most necessary.

Gilbert's Island shore protection (No. 4, sheet 73).—Some 1,000 feet of bank were protected at the lower end of Gilbert's Island. At this place and on a part of the Illinois shore work piers of brush and stone were constructed at intervals of 50 to 100 feet, and between the bank was sloped and covered with gravel extending out to a depth of from 5 to 10 feet.

Wing-dam No. 4 (sheet 73).—This dam extends out from the Illinois shore opposite foot of Island No. 449; was begun July 17, and finished August 2, 1879. It is 700 feet in length with shore protection 100 feet long and spur at outer end 40 feet. Crest at shore end 2 feet above low-water, at outer end 1 foot below.

Denmark Island Dam (No. 7, sheet 73).—This closing dam is 1,500 feet in length; a portion, some 700 feet, extends across a sand bar, but the remainder was built in deep water, ranging from 10 to 20 feet below low-water. In the deeper portion great difficulty was experienced in sinking mats on the line. This dam was carried to an average height of about 6 feet above the bottom.

Drift Slough Dam.—A layer of brush and rock was placed across the head of Drift Slough to prevent it from widening.

Dredging.—From an examination of the east channel in July, 1879, it became evident that a good channel could not be maintained even with the increase of volume attributable to the Gilbert's Chute Dam, and accordingly dredging was resorted to with a view to assist the operations of the dams and open a channel for boats, but the water falling very rapidly left the channel in very bad shape and much trouble was experienced. The dredges worked with indifferent success, the sand shifting very rapidly and obliterating in great part the results of their labors. The main object was to open a cut along the Illinois shore from the pocket above dam No. 3 to the deep water below dam No. 4, and this was finally accomplished after many interruptions, but in a short time nearly the whole cut had filled up. An examination, however, made in the spring of 1880, shows that the main channel now follows the course of this cut and bids fair to be lasting and good.

A great deal of time was spent in deepening by dredging the square crossing between dams 2 and 3, and by this means a tolerable channel was kept open for boats. A cut was also made along Gilbert's Island from above dam No. 2 to a point some distance below, but this afforded relief for a short time only as it soon filled up again.

Wing-dam No. 2 (sheet 73).—Runs out from the east side of Gilbert's Island, starting from a point about 800 feet above the square crossing and extends 700 feet to the shoal water on the bar. It was brought up to an average elevation of about low-water mark. More material is required to complete this dam and give its crest the proper elevation.

Wing-dam No. 1 (sheet 73).—Runs out from the east shore of Gilbert's Island from a point about 2,400 feet above No. 2 and is about 700 feet in length, extending to shoal water on the bar opposite. This dam is not yet completed.

Wing-dam No. 3 (sheet 73).—Was begun November 17 and occupied a part of the working force until the termination of the working season, December 10, 1879. This dam runs out from the Illinois shore from a point a short distance below the square crossing some 1,200 feet, and consists of 2 layers of brush covered with rock.

Removal of portion of dam No. 3.—A survey was made by Inspector O. N. Chaffee in March, 1880, for the purpose of ascertaining what changes had occurred since the previous survey of July, 1879. It was found that the best channel ran down the Illinois shore over dam No. 3, and past the end of dam No. 4. The square crossing which had been the channel of the year before was found to be filling up and it was accordingly determined to remove a portion of dam No. 3 by dredging, in order that boats might pass down the Illinois shore where the best water existed. Work was begun on April 5 and completed on the 15th, some 430 feet of the dam being taken out and the material chiefly deposited on dam No. 4. Dredging was done with dredge and outfit hired by the day. This new channel is straight and comparatively deep, and if it can be maintained, of which there now seems to be no reasonable doubt, the problem of the improvement of this locality will have been solved.

Summary of work at Gilbert's Island from its commencement up to and including June 30, 1880.

Description.	Linear feet.	Rock.	Brush.	Gravel.	Sand.	Amount.
		Cubic yds.	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*	
Gilbert's Chute Dam	1,775	7,246	3,881	1,382		$12,354 12
Wing-dam No. 5		929	1,041			1,834 96
Illinois shore protection	10,050	3,235	1,803	8,902		14,392 98
Gilbert's Island shore protection	1,000	300	190	500		1,220 04
Wing-dam No. 4	700	1,022	1,592			2,296 17
Denmark Island Dam	1,500	3,040	1,885			5,530 46
Drift Slough Dam	200	121	115			227 11
Wing-dam No. 2	700	864	660	163		1,792 29
Wing-dam No. 1	700	1,032	957	721		2,514 05
Wing-dam No. 3	1,200	1,490	1,563			3,259 34
Dredging					28,782	5,626 26
Removing part of dam No. 3	430					1,296 76
Total		19,279	13,687	11,668	28,782	52,354 54
Superintendence, office expenses, &c						3,764 92
Total						56,119 46

Of the above amount the sum of $11,724.20 was expended prior to July 1, 1879.

I take pleasure in calling attention to the zealous and able manner in which the inspector, Mr. O. N. Chaffee, has carried on the various works in the vicinity of Gilbert's Island which have been superintended by him from the beginning.

IV.—SLIM ISLAND.

The works proposed for the locality, which are included in the project for the improvement of the river from just below Clarksville, Mo., to Hamburg, Ill., a distance of 14 miles, consist in closing several side channels of the river, to confine all the water in one channel, and of spur-dams to contract the water-way and direct the currents. The original project of Major Farquhar received the indorsement of the "Board of Engineers on low-water navigation of the Mississippi River" November 15, 1878, and the approval of the Chief of Engineers November 26. After due advertisement the contract for the works at Slim Island was awarded to Fruin & Co., of Saint Louis, who pushed their work energetically and satisfactorily to the government.

Carroll Chute Dam (No. 1, sheet 77).—Work was begun on this dam April 15, 1879, and it was completed in the latter part of September. It is 678 feet in length, and was built to a height of 2 feet above low-water. An examination of the dam made this spring shows that it has sunk about 3 feet evenly along its length.

Slim Island shore protection (No. 1, sheet 77).—This work was begun May 13 and completed September 17, 1879, during which time 2,966 feet of caving bank were protected from abrasion, beginning at the head of the island and extending down its eastern shore. It is now in excellent condition.

Coon Island Dam (No. 2, sheet 77).—This dam is 428 feet long, with shore protection at each end of 100 feet. The crest of the dam was carried to a height of 1 foot above low-water. Work was begun June 2 and finished June 13, 1879. This dam has settled but slightly.

Grimes's Island Dam (No. 3, sheet 77).—This dam is 1,204 feet long, with 100 feet shore protections. The greater part of the dam is on a sand-bar, which is dry at low-water, and it was built to prevent the channel from cutting through this bar. Commenced June 13 and finished July 14, 1879. The dam remains in excellent condition.

Spur-dam above head of Slim Island (No. 4, sheet 77).—This dam is 700 feet long, with 100 feet shore protection and 200 feet T-head at outer end. It was built to a height of 1 foot above low-water, was begun July 14 and completed August 6, 1879, and is now in excellent condition.

Slim Island Chute Dam (No. 5, sheet 77).—This dam closes Slim Island Chute, and is 504 feet in length, with shore protections of 100 feet at each end. Greatest depth at low-water, 7 feet. It was carried to a height of 2 feet above low-water, and was completed September 16, 1879. The examination of this spring shows that it has settled about 3 feet.

Shore protection, head of Carroll's Island (No. 2, sheet 77).—This protection is 300 feet in length, extending from the head of the island down the western shore. Begun September 13 and finished September 26, 1879. It is now in excellent condition.

Shore protection, foot of Grimes's Island (No. 3, sheet 78).—This work extends from foot of Grimes's Island up-stream 690 feet. Begun September 29, finished October 6, 1879, and is now in very good condition.

Illinois shore protection (No. 4, sheet 77).—Some 1,500 feet of bank were protected on the Illinois shore opposite Grimes's Island, the work being done between October 6 and October 20, 1879. It is now in fine condition.

As the result of the works in the vicinity of Slim Island, we note great improvement in the Carroll's Island crossing, the first two crossings below head of Slim Island, and the crossing at foot of Slim Island, and as these were formerly the worst obstructions in that part of the river included in the scope of the works already constructed, our labors may be said to have been reasonably successful.

To the inspector, Mr. J. H. Morrison, who has superintended the works in vicinity of Slim Island from their commencement, great credit is due for the intelligent and zealous discharge of his duties.

Summary of work at Slim Island from its commencement up to and including June 30, 1880.

Description.	Linear feet.	Rock, at $1.03.	Brush, at $0.66.	Amount.
		Cubic yds.	*Cubic yds.*	
Carroll Chute Dam	678	4,216.81	1,828.14	$5,549 90
Slim Island shore protection	2,966	7,450.39	3,536.09	10,007 72
Coon Island Dam	428	1,207.11	717.16	1,716 64
Grimes's Island Dam	1,204	2,034.59	1,771.28	3,264 67
Spur above head Slim Island	700	1,865.76	1,825.19	3,126 35
Slim Island Chute Dam	504	3,381.16	1,223.82	4,290 31
Carroll's Island shore protection	300	565.48	262.00	755 36
Grimes's Island shore protection	690	1,109.26	485.63	1,463 06
Illinois shore protection	1,500	2,516.08	1,231.61	3,404 42
Total		24,346.64	12,880.92	33,578 43
Superintendence and office expenses				4,384 66
Total expended				37,963 09

Of the above amount the sum of $13,319.60 was expended prior to July 1, 1879.

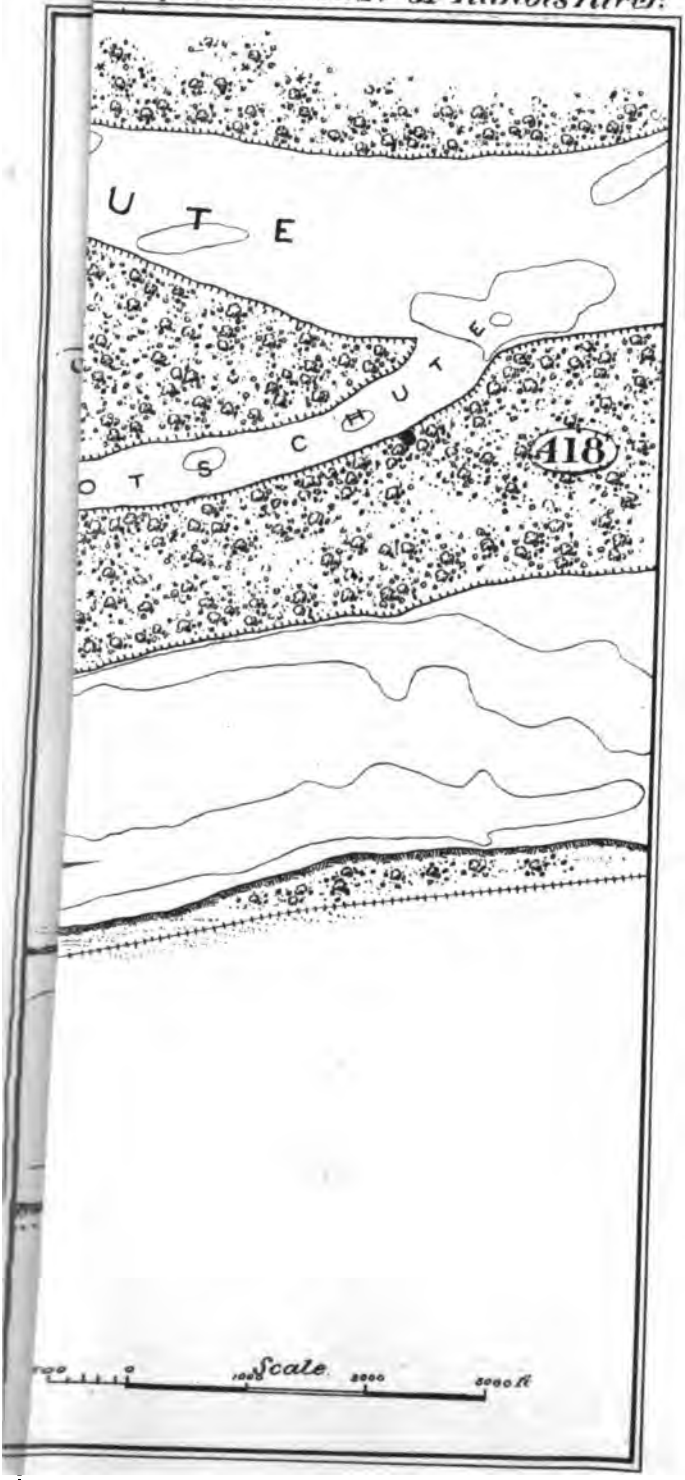
I append the following memoranda of Capt. B. D. Greene, Corps of Engineers, in reference to works of improvement on Upper Mississippi River, &c.:

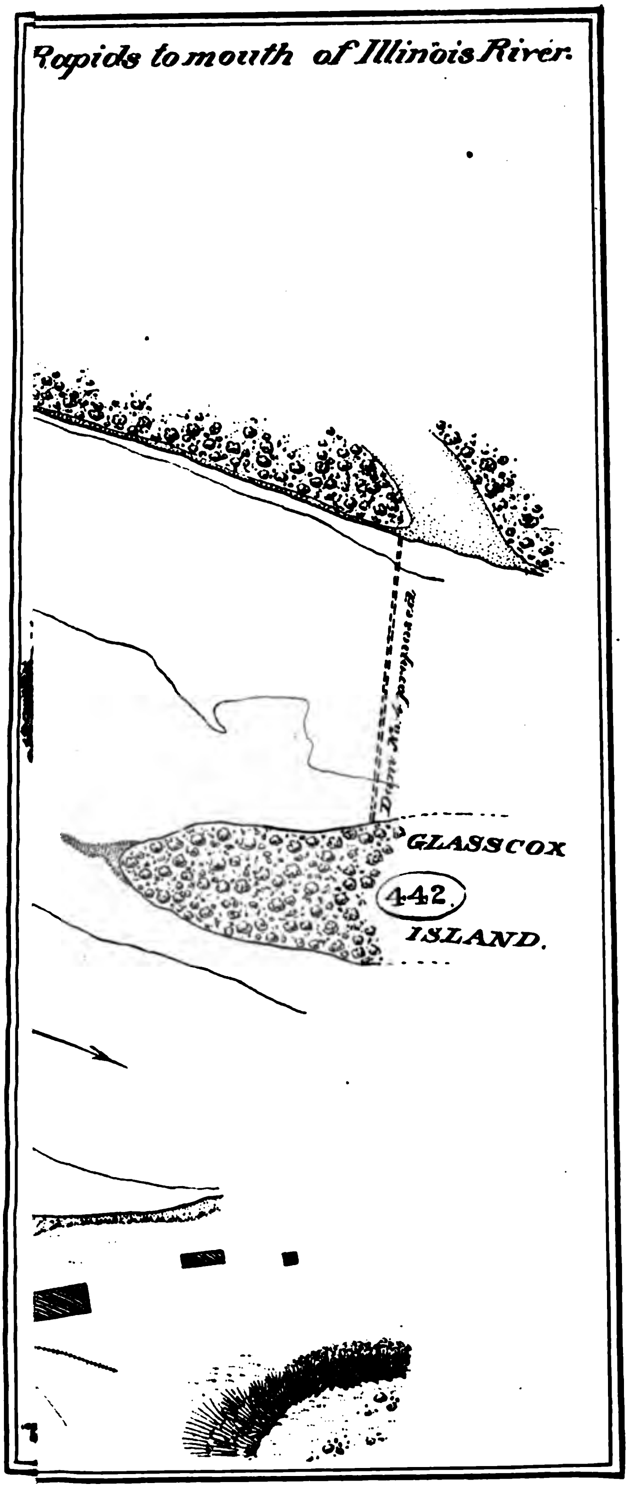
MEMORANDUM.

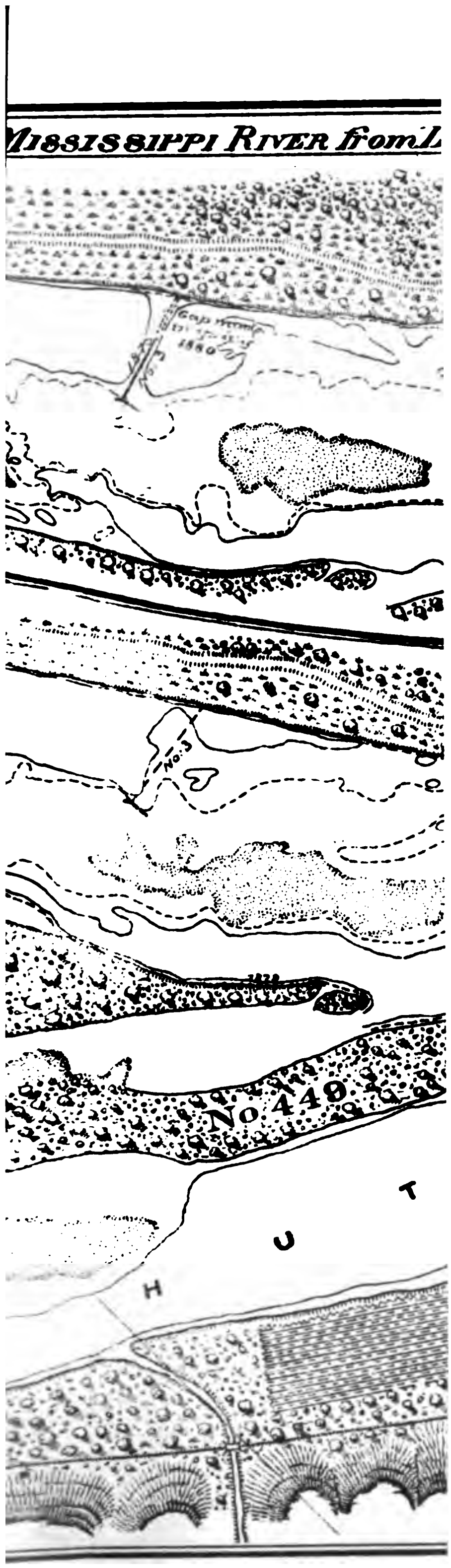
I. The closing of chutes and confining the river to a single channel is of the first importance, but this should not be done unless there is money sufficient to protect the banks at the same time.

8

s Rapids to mouth of Illinois River.




Rapids to mouth of Illinois River.
Dyke No. 4 proposed
GLASSCOX
442
ISLAND.


RIVER from
No 449
No. 3

11

The construction of wing-dams near the upper side of sand-bars to hold the sand in the eddy below is important both in retaining the sand and rendering the channel permanent.

It is not necessary or desirable to hold or force the river to a uniform width of channel, or to endeavor to straighen it or give it an easy curve.

METHODS OF CONSTRUCTION.

II. Some modifications must be made in present construction of dams and shore protection. With any considerable amount of money, the quantity of brush accessible will not be sufficient to make any calculations upon its use. The main dependence must be placed upon rock; when gravel can be found, rock and gravel will do well. In closing a chute, if the water is 15 or 20 feet deep, I believe rock alone would not settle much. It might need a little brush or gravel at the angles at ends. In shoaler water the sand is less firm and a dam of rock alone would probably sink. Gravel foundation would do with gravel backing. If gravel cannot be had, perhaps an apron and even a whole foundation can be made of poles 5 to 8 inches in diameter, covered with boards with intervals of 2 to 4 inches. It is not necessary that mats for shore protection should be 1 foot thick; large willows 30 to 40 feet long can be made into rafts and used instead of mats along the shore where the current is usually gentle and they can be sunk.

III. The way to do this kind of work is by hired labor, for two reasons: 1st. If done by contract the economical conditions are frequently not the same for the government and for the contractor; therefore the latter must allow a wide margin, which greatly increases the cost of the whole work. For example: while at work upon a dam a bank is discovered to be cutting seriously a mile or two below. It may be for the interest of the government to change work to that point without delay; this may be attended with considerable additional expense to the contractor, or the construction may have to be unusual, or only temporary; and for all these variations the government must not only pay, but pay also for the chance that they may occur, because no prudent contractor would fail to consider this matter well.

2d. As no contractor can be certain of more than the one work he has in hand, he does not feel able to get a suitable plant, and attempts to get along cheaply, thereby causing the work to drag, even if it does not fail altogether.

I believe the advantages the government would have in these two points would more than balance the disadvantages under which public works are usually conducted by the public itself.

IV. Work will generally be done upon parts of the river, such that an outlay of $50,000 at least will be required in a season. In quartering men a quarter-boat will be better than putting men in tents; the advantages are, health, convenience, comfort, and economy.

The outfit for one of these works should consist of one steamboat and six or eight barges, one quarter-boat for men, one for overseer, and from four to six small boats, with proper outfit of lines, tools, &c. In most places where work will first be done the rock must be brought several miles.

It is therefore desirable that barges should go in pairs, both for economy and convenience of handling. In building dams probably no better way of handling rock than the one now in practice is to be desired, but in putting rock on shore it would seem that a derrick might be used to advantage.

SUMMARY FOR FISCAL YEAR ENDING JUNE 30, 1880.

Improvements at Canton, Mo	$10,739 38
Improvements at Hannibal, Mo	822 51
Improvements at Gilbert's Island	44,395 26
Improvements at Slim Island	24,643 49
Maps and surveys	2,090 54
Total expended	82,691 18

Five hundred thousand dollars could be well spent every year on this division of the river until the work of improvement is completed, and such a sum would be more economical than smaller ones, for obvious reasons.

For reasons stated above in report on "Improvement Mississippi River, Saint Paul to Des Moines Rapids," I would also respectfully request that a dredge and outfit may be procured for use on this division of the river at a cost not to exceed $15,000.

It is proposed during the present season, with the amount now available, to continue the works at Canton, Gilbert's Island, and Slim Island, and to inaugurate improvements at Gregory's Bar and Westport Chute, and such other points as may prove most troublesome during the coming low-water.

ABSTRACT OF APPROPRIATIONS FOR IMPROVEMENTS MISSISSIPPI RIVER FROM DES MOINES RAPIDS TO ILLINOIS RIVER.

By act approved June 18, 1878	$100,000
By act approved March 3, 1879	40,000
By act approved June 14, 1880	100,000
	240,000

Money statement.

Improvement of Mississippi River from Des Moines Rapids to mouth of Ohio River.

July 1, 1879, amount available	$45,236 66
July 1, 1880, amount expended during fiscal year	45,236 66

Improvement of Mississippi River from Des Moines Rapids to mouth of Illinois River.

July 1, 1879, amount available	$40,000 00	
Amount appropriated by act approved June 14, 1880	100,000 00	
		$140,000 00
July 1, 1880, amount expended during fiscal year		37,454 52
July 1, 1880, amount available		102,545 48
Amount that can be profitably expended in fiscal year ending June 30, 1882.		500,000 00

Abstract of proposals received and opened this 27th day of August, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. A., for building dams and shore protections of brush and stone in the Mississippi River, at Canton Chute, near Canton, Mo.

Number.	Names and residences of bidders.	6,000 cubic yards stone.		5,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	Fred. W. Menke and John H. Bitler, Quincy, Ill	$1 49	$8,940	$0 80	$4,000	$12,940
2	H. S. Brown, Hamilton, Ill	1 30	7,800	90	4,500	12,300
3	Fruin & Co., Saint Louis, Mo	1 60	9,600	85	4,250	13,850
4	Whitney & Son, Keokuk, Iowa	1 21	7,260	63	3,150	10,410
5	Jacob Ebert, Quincy, Ill	1 26	7,560	64	3,200	10,760
6	Samuel S. Sample, Keokuk, Iowa	1 09	6,540	77	3,850	10,390

FINAL REPORT ON SURVEY OF UPPER MISSISSIPPI RIVER, FROM SAINT PAUL, MINNESOTA, TO MOUTH OF ILLINOIS RIVER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July —, 1880.

GENERAL: I have the honor to present as an appendix to my annual report a final report on a continuous survey of the Upper Mississippi River, from Saint Paul, Minn., to the mouth of the Illinois, made under direction of Maj. F. U. Farquhar, Corps of Engineers, in 1878 and 1879.

AUTHORITY FOR THE SURVEY.

The act approved June 18, 1878, made an appropriation for the improvement of the Upper Mississippi River both above and below the Des Moines Rapids.

The officer in charge wrote the letters from which the following extracts are taken:

[Extract.]

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 28, 1878.

GENERAL: * * * No complete or connected survey of this part of the river Saint Paul to Des Moines Rapids) has ever been made, and such a survey is absolutely necessary for a proper study of the river. Using the partial surveys already made, a connected survey can be made for $30,000. This would enable me to put three parties into the field, and would much facilitate the construction of the proposed work mentioned below. * * *

F. U. FARQUHAR,
Major of Engineers.

CHIEF OF ENGINEERS, U. S. A.

[Extract.]

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1878.

GENERAL: * * * No surveys have been made of the Mississippi River between the Des Moines Rapids and the mouth of the Illinois on which any project for works of improvement can be based. Last year examinations of the worst bars were made, but the examinations were not detailed nor extensive enough, and before any works are constructed surveys must be made. I propose sending two parties out to make such surveys at once, and then complete a good survey of the river from Keokuk to the mouth of the Illinois River. Such surveys can be made during the present season by two parties and will cost about $30,000.

F. U. FARQUHAR,
Major of Engineers.

CHIEF OF ENGINEERS, U. S. A.

The project for surveys, dated June 28, as also the project dated July 1, were approved by the Chief of Engineers under date of July 8, 1878.

The organization of a special party (No. 6) for a more minute survey of a limited portion of the river was authorized by the following letter:

[Extract.]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., September 14, 1878.

SIR: Your letter of the 9th instant, reporting that you have selected the portion of the Mississippi River between Burlington, Iowa, and Fort Madison, Iowa, for the observations required by the Board of Engineers, constituted by S. O. 71, current series, to report upon improvement of the low-water navigation of the Mississippi River, &c., has been received. To enable you to carry on the observations proposed by the Board, you are authorized to employ * * * , &c.

JOHN G. PARKE,
Major of Engineers.

Maj. F. U. FARQUHAR,
Corps of Engineers.

PREVIOUS SURVEYS.

The surveys that had been previously made on the Upper Mississippi River were surveys of General G. K. Warren, 1866–1869, of detached localities principally above Winona Minn., and surveys of detached localities made by Col. J. N. Macomb, 1874–'75, under the appropriation for "Transportation routes to the seaboard."

The great changes in the channel of the river that had occurred subsequent to these surveys, and the want of continuity of the surveys themselves, made them of little use for planning and estimating the immediate work to be done for the improvement of particular localities, except as furnishing valuable data for studying changes in the river bed. It was thought best, therefore, to make a continuous survey from Saint Paul to the mouth of the Illinois excepting only the Des Moines and Rock Island Rapids, where there were already very thorough hydrographic surveys completed for the purposes of the improvement at those places.

APPORTIONMENT OF THE WORK.

There were originally contemplated five parties, three for the division above Des Moines Rapids and two for that below; but, owing to the lateness of the season when work was begun and a desire to finish it before winter, it was found necessary to add several sub-parties.

Party No. 1, Assistant F. Terry in charge, was at first intended to work between Hastings, Minn., and Lynxville, Wis., using the surveys of General Warren and Colonel Macomb when possible. It was found, however, that even with this assistance the district was too long to be covered during the remainder of the season, and a part of the field work was therefore performed during the spring of 1879.

Examination of that portion of the river above Hastings also made it evident that to plan a system of improvements suitable to its present condition a new survey would be necessary, and it was accordingly made in June, 1879, by a party under Assistant Engineer J. L. Gillespie.

Party No. 2, under Assistant F. W. Lehnartz, operated between Lynxville, Wis., and Savanna, Ill. This district was also found to be too long to be covered in the time allotted, and two sub-parties were added, one survey, under Assistant Max. E. Schmidt, running from Bellevue, Iowa, to Golden's wood-yard, and the other, from Sand Prairie to Savanna, was made by Assistant C. W. Durham with the crew of the United States steamer Montana.

Party No. 3, under Assistant J. P. Allen, operated between Savanna and Slater's wood-yard, 7 miles above Burlington, Iowa.

Special party No. 6, under Assistant G. A. Marr, worked from Slater's wood-yard to the head of Des Moines Rapids. To this party was given a shorter section of river than to the others, that it might make a more perfect and detailed survey for purposes of study, and to it was assigned the duty of procuring information required by the Board of Engineers constituted by Special Orders No. 71, 1878 (see letter above), on low-water navigation of the Mississippi and Missouri rivers. A special report on the work of this party was made to General Z. B. Tower, senior officer of the Board, under date of February 5, 1880.

Party No. 4, under Assistant Henry Custer, operated between Keokuk, Iowa, and Hannibal, Mo.

Subparty No. 7, under Assistant J. H. Morrison, operated between Hannibal and the foot of Clarksville Island.

Party No. 5, under Assistant F. A. Churchill, from foot of Clarksville Island to the mouth of the Illinois River.

METHODS OF SURVEY.

Transit lines.—Transit lines were run in lengths of from 15 to 20 miles from one azimuth station to another, at which stations observations of Polaris were made for checking the azimuth. They followed the easiest

ground, usually the railroad or a common road, or, in default of these, one bank of the river. Distances on this line were carefully chained and topography sketched.

Stadia lines.—Stadia lines followed the river bank, locating points for topography, and also the sounding stations built in advance by a special party of two or three men in a skiff.

At intervals this stadia line was connected with the transit line so as to check it for distance and azimuth.

In some cases (notably party No. 1) instead of a transit line a system of triangulation was used with very good results. All important branches of the stream were surveyed with stadia as well as the main river, but it was found impossible within the limits of the funds allotted and time at disposal to make a survey extending from bluff to bluff or of the entire river bottom.

Level lines.—Level lines were run along the river bank, with bench marks at frequent intervals and numerous determinations of the water surface (every 1,000 feet). A check line of levels was also run connecting the benches.

At all towns and steamboat landings benches had been established and extreme low-water determined during low-water of 1877. These benches were leveled in and a low-water line obtained as shown in Plate II. Frequent water gauges were established and the water surface recorded daily during the time of survey. Each party started its levels from an assumed datum which was afterwards reduced on a general profile of the river to elevations above sea level. These last are figured from the recent determination of altitude of Lake Superior by the lake survey and determination of low-water at Saint Paul by Henry Gannett, of United States Geological Survey. A list of the permanent bench marks, with descriptions of the same, is included in this report, giving elevations of bench marks and low-water above sea level.

Extreme low-water is 0.75 foot below low-water of 1877, as determined at each bench mark during the very low-water of that season. In that year an unusual low-water occurred (the lowest since 1864) and was of six weeks' duration, extending over the whole upper river, and giving a remarkably good opportunity for determining the low-water elevation at each place. The plane of low-water then determined agrees with the low-water of 1864 recorded at Rock Island and Keokuk, the only two places where low-water of 1864 was reliably recorded. At Winona and La Crosse Bridges, gauges set to the above determination of low-water of 1864 agreed closely with gauges previously set by the bridge engineers from alleged extreme low-water marks, and the inference is that the gauges and low-water line are quite correct. (See profile sheet.)

During 1879 a large number of gauges were read at various points along the river, and these have been platted for more convenient study of the differences of ranges of water surface, &c. (See sheet of gauge-readings.)

Extreme low-water occurring during the winter or from ice gorges has not been considered in determining the low-water line as not influencing navigation.

Sounding.—The sounding was done either with steam launch or row-boat, the latter propelled by two oarsmen; usually the assistant in charge of the party accompanied the sounding party. The party consisted of the sounder, two oarsmen (or pilot and engineer of steam launch), recorder, and steersman. The sounder was furnished with a pole marked in feet and tenths (burned in), and from 12 to 20 feet in length, and with a light

cotton rope having a loop on the end to pass around the sounder's wrist This cord being divided into feet by means of tags, permitted sounding to a greater depth than the length of the pole. Depths greater than the length of the pole and cord combined were generally recorded as $\frac{20}{0}$, or no bottom at 20 feet where 20 feet represents such combined length. When deemed advisable the lead was used. All the soundings were made by time intervals, except in special cases where the sextant was used to give additional accuracy, or a stadia rod on the boat was read at intervals from an instrument on shore. The assistant engineer in charge kept the sounding record. The sounding stations were built by a party in advance of the stadia work. They worked down stream, and two men with a skiff on the river above Hastings could put up stations averaging 400 feet apart, and constructed as shown in Plate I, for about 4 miles of river per day. The sounding stations were numbered from 1 to 10 in series on each side of the river. In party No. I the stations were marked by sticks nailed upon trees or posts, so as to form Roman numerals, and then whitewashed, a method much employed on the Lake Survey. They were well adapted to the Mississippi River survey, and being easily found and quite permanent, they are particularly useful where resurveys are contemplated. The stations were placed from 100 to 800 feet apart, the average being about 400 feet, but at localities where closer observations were required, namely, at the different channel crossings, they average about 200 feet apart. Besides the sounding stations, Plate I also shows the form of various instruments used on this survey, which were found in practice to be well adapted to the work.

Gaugings.—Frequent gaugings of the river were made, and the methods and formulæ of Humphreys and Abbot employed. In party No. 6 special accuracy was aimed at, and a description of the work is furnished in a special report to Col. Z. B. Tower, dated February 5, 1880, and also in an appendix accompanying my annual report for 1879–'80.

The gaugings made by other parties were more or less approximate, and the *less rigorous* methods of Humphreys and Abbot were applied. Usually a base of 200 feet was measured along the river bank at a suitable place, and three parallel lines of soundings made across the river perpendicular to the axis of the stream.

The average of the three areas obtained was considered the mean area for the stage at which the soundings and gauging were made. The path of each float was located by intersections, a theodolite being stationed at some distance below the base for that purpose. These paths were platted on a plan of the gauging section, and the measured mid-depth velocity laid down to scale perpendicular to the line of mean section. Through the extremities of these ordinates a line was drawn by means of flexible splines, and used for interpolating 10 mid-depth velocities corresponding to 10 sections of equal length, into which the mean section was now divided. The area of each section was multiplied by the interpolated mid-depth velocity, and the sum of all the 10 multiplied by 0.95 gave the discharge. Reductions to low-water were made under the assumption that S, calculated for the given gauging and stage, retained the same value at low-water. The new area of mean section was calculated and new values of V and Q determined (see Plate III). The adopted low-water discharges are given in the profile sheet at various points, together with the drainage areas of the different tributaries. Plate IV gives a diagram of the discharge at various stages as measured by the careful methods employed at Burlington.

PLATE No. 1.

IVER from S^T Paul to Grafton

ging Float

Water Gauge.

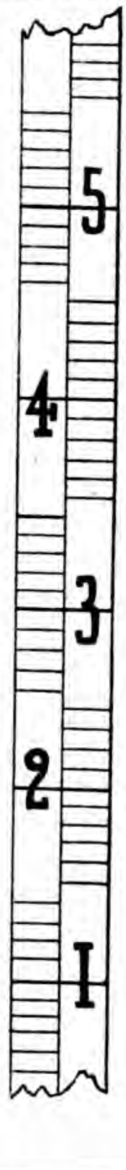


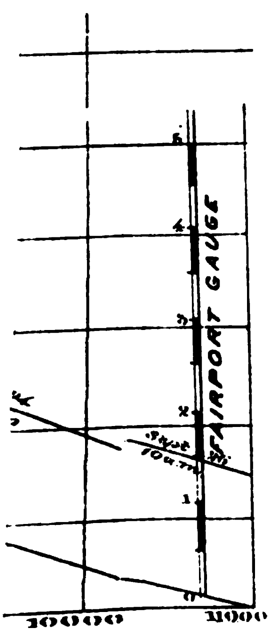
PLATE No: 2.

from St Paul to Grafton.

ILE

ND to FAIRPORT

ning the low water line



S^T Paul to Grafton.

nd. Ills.

SCALE

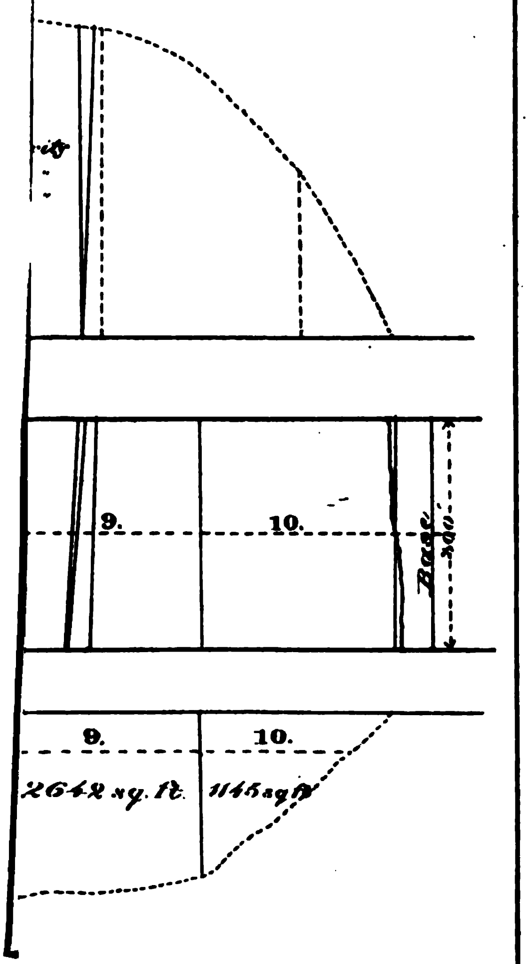
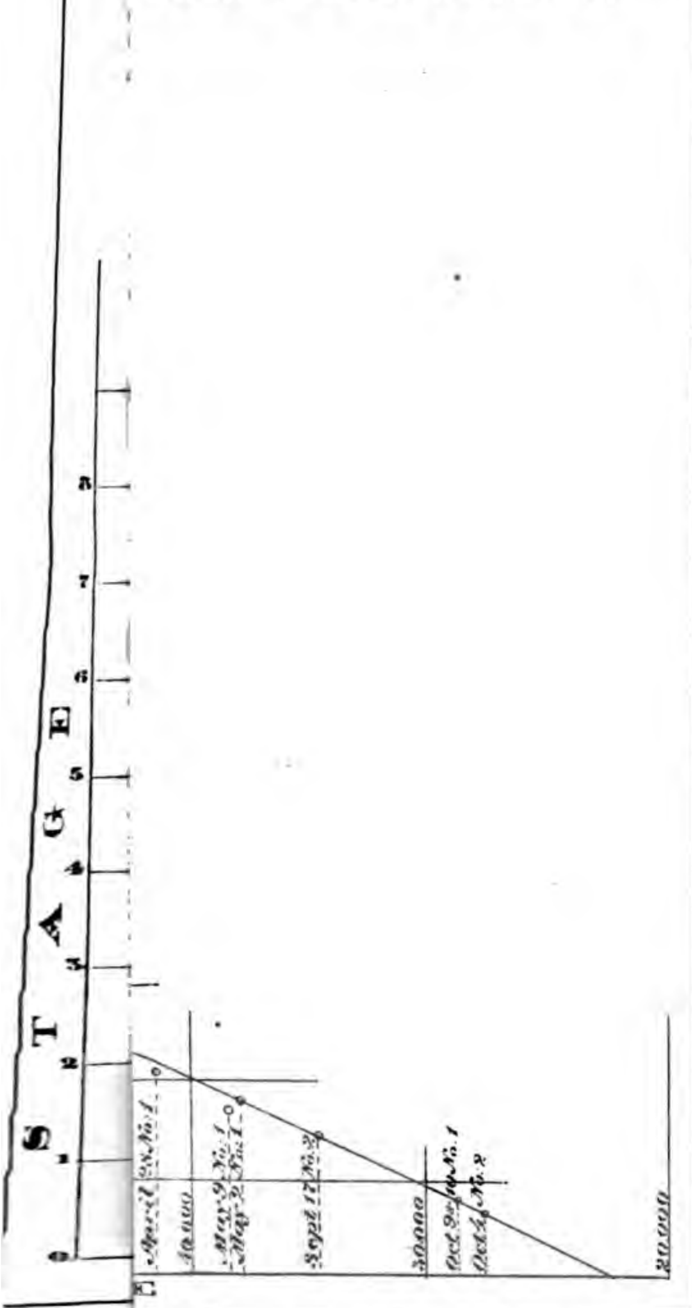


PLATE No: 4.

ER from St. Paul to Grafton.



LATITUDE AND LONGITUDE.

Application having been made by Major Farquhar to Major Comstock, superintendent of the Lake Survey, the positions in latitude and longitude of the following-named points were furnished:

Stations.	Description of reference points.	Latitude.			Longitude west from Greenwich.		
		°	′	″	°	′	″
Galena, Ill	To east corner Miner's house, N. 10° 52′ W., 164.7 feet; to east corner Frazer's house, N. 84° 28′ E., 180.7 feet; to northeast corner of Methodist Episcopal Church, S. 54° 14′ W., 338 feet	42	25	09.50	90	25	52.05
Red Wing, Minn	Astronomical post northwest corner court-house yard	44	33	44.16	92	31	59.25
	Spire of Catholic church			44.64			49.66
La Crosse, Wis	In court-house square, post 72′ 10″ from southeast corner court-house, 49′ 9″ from southwest corner of jail	43	48	50.1	91	14	48
Rock Island, Ill	Astronomical post on United States arsenal grounds	41	31	03.41	90	33	40.10
	Southeast corner of guard-house			01.51			45.99
	Gas-pipe △ 2, Rock Island Rapids improvement survey			03.69			40.39
Burlington, Iowa	South Hill, public square	40	48	22.04	91	06	25.35
Louisiana, Mo	Astronomical post, northwest corner High School yard	39	27	14.30	91	03	06.30
	Northeast corner High School building			12.84			08.18
	Southeast corner of brick house on northwest corner of Noyles and Fourth streets			15.25			07.42

The determinations at Rock Island, Red Wing, and Louisiana, were made by Lieut. C. F. Powell in the autumn of 1878.

Gauging measurements on the Upper Mississippi, by the Humphreys and Abbot method of mid-depth floats.

Locality.	Date.	Stage.	Width.	Wetted perimeter.	Area.	Mean velocity.	Discharge.	Adopted low-water discharge.
		Feet.	Feet.	Feet.	Sq. ft.	Ft. p. sec.	Cu. ft. p. sec.	Cu. ft. p. sec.
Frenchman's Bar	1874	5.8					20,091	5,000
Wabasha	1878	3.5	1,500	1,502	12,790	1.658	21,212	10,000
Winona	1878	1.3	1,476	1,477	8,651	1.856	16,061	11,000
Do	1880*	8.1	1,785	1,788	22,331	3.237	72,298	11,000
Johnsonsport	1878	1.0	1,570	1,573	15,637	1.553	16,473	14,000
Below mouth of Wisconsin	1878	0.96	1,237	1,239	16,161	1.270	20,527	17 000
Lyons	1878	3.1	1,736	1,737	23,227	1.615	37,512	18,500
Princeton	1878	1.1	2,087	2,088	21,599	1.284	27,743	19,000
Rock Island	1878	2.1	2,444	2,445	19,109	1.586	30,313	19,000
Do	1880†	18.4	2,737	2,740	60,880	4.3456	251,348	19,000
Burlington	1879	7.2	2,406	2,410	34,791	2.975	103,536	22,000
Do	1879	0 7	2,333	2,335	19,749	1.414	27,929	22,000
Canton	1878	5.2	2,339	2,341	25,571	2.403	61,445	26,000
Hannibal	1878	1.5	1,100	1,102	17,086	2.267	38,741	30,000

* River up to top of its banks. † Top of highest well-authenticated flood.

List of permanent bench marks from Saint Paul, Minn., to Grafton, Ill.

[Survey of 1878 and 1879.]

Bench mark.	Description.	Elevation above sea.	Low-water above sea.
		Feet.	*Feet.*
1	On down-stream corner of inner edge of coping stone of abutment at east end of Chicago, Milwaukee and Saint Paul Railroad Bridge at Saint Paul..	697.403	678.500
2	On extreme upper end of up-stream nosing of east shore pier of the Wabasha Street wagon bridge, Saint Paul	697.722	678.100
3	On top of the ring-bolt in rock ledge, 15 feet from river bank and 50 feet up stream from warehouse at Newport, Minn	686.256	672.5[illegible]
4	On top of top-stone at end toward the river of retaining wall of railroad culvert over Franklin Cooley, 1 mile below Nininger, Minn	687.612	....
5	On top of draw-pier under engine-house on down-stream side of Chicago, Milwaukee and Saint Paul Railroad Bridge at Hastings	687.931	663.7[illegible]
6	On white elm, 60 feet from left bank of river and 850 feet above the upper spur-dam from the left bank, at Smith's Bar, 5 miles below Prescott, Wis..	673.194	660.9[illegible]
7	On elm, 100 feet from left bank of river, on up-stream side of rocky point, 2,800 feet below warehouse, at Diamond Bluff, Wis	672.281	....
8	On iron pin set in large foundation stone under up-stream corner towards river of city freight shed at Red Wing, Minn	673.820	657.7[illegible]
9	On iron spike in root of largest cottonwood tree on the beach at Waconta, Minn., 100 feet from the right bank and opposite foot of Island No. 28	665.257	656.4[illegible]
10	On down-stream corner toward river of stone foundation of J. B. Wilson & Co.'s (Knapp, Stout & Co.) warehouse at Reed's Landing, Minn	671.412	[illegible]
11	On first projecting stone below floor level at up-stream corner towards river of H. W. Holmes's warehouse at Wabasha, Minn	667.330	654.[illegible]
12	On projecting stone of foundation at up-stream corner of river front of M. Polin's warehouse at Alma	660.371	649.1[illegible]
13	On up-stream corner toward river of wooden door-sill of O'Neil's new brick warehouse at Minneiska, Minn	659.827	643.1[illegible]
14	On top of foundation-stone at lower floor level at down-stream corner toward river of Hulfner Bros.' warehouse at Fountain City, Wis	649.561	637.[illegible]
15	On copper bolt set in stone, 75 feet from left bank of river at Wild's Landing, Wis	659.901	......
16	On top of second step from ground at outer corner next river of Centre street entrance of Second National Bank, Winona, Minn	655.842	632.4[illegible]
17	On up-stream corner of stone-work under wooden door-sill in river front of Haines & Holmes's warehouse, Trempealeau, Wis	638.551	626.7[illegible]
18	On down-stream corner of top stone of down-stream corner of railroad culvert under large fill 200 feet from river and 125 feet below limekiln in upper part of Dresbach, Minn	640.393	623.5[illegible]
19	On extreme up-stream front of cap-stone of first pier on Minnesota side of Chicago, Milwaukee and Saint Paul Railroad Bridge above La Crosse, Wis.	643.753	621.2[illegible]
20	On bottom of door-post on up-stream side of lower door on river front of Western Progress building at Brownsville	629.253	615.3[illegible]
21	On up-stream corner of door-sill, second floor, river front, of last stone building down stream at Bad Axe, Wis	632.756	610.2[illegible]
22	On up-stream corner of sill of door next river on ground floor of Wilcox & Orrs warehouse at Victory, Wis	620.725	606.640
23	On southeast corner of door-sill at down-stream corner of G. Kerndt & Bros.' warehouse at Lansing, Iowa	619.866	605.49[illegible]
24	On foundation-stone at up-stream corner of river front at floor level of Bright's warehouse at Lynxville, Wis	622.044	601.76[illegible]
25	On southwest corner of stone in second course from top of west wing of south abutment of culvert, 400 feet below mouth of Paint Creek, at Johnsonport, Iowa	598.453	....
26	On southeast corner of elevator above S. McGregor, Iowa	623.067	....
27	On top of foundation-stone, at up-stream corner next river, of platform of railroad depot at Clayton, Iowa	618.369	594.670
28	On river side of door-step on up-stream side of Dr. Grinter's building at Glen Haven, Wis	611.850	592.0[illegible]
29	On top of foundation-stone at up-stream corner of river front at floor level of G. Prior's warehouse at Cassville, Wis	612.906	588.2[illegible]
30	On down-stream corner of large stone door-step of Specht's house, at Specht's Ferry, Iowa	607.857	583.100
31	On top of down-stream ring-bolt in front of A. H. Gibb's store on levee at Dubuque	595.923	578.0[illegible]
32	On northeast corner of projecting bottom of foundation-stone at northeast corner of J. M. Case's barn at Bellevue, Iowa	587.842	571.122
33	On nail in top of white-ash stump 18 inches high, 10 inches diameter, 1,000 feet south of Golden's house at Golden's wood-yard, Iowa	583.535	569.170
34	On southeast corner of door-sill of door at southeast corner of first floor of engine-room of Racine and Milwaukee elevator at Savanna, Ill	584.578	565.371

List of permanent bench marks from Saint Paul, &c.—Continued.

Bench mark.	Description.	Elevation above sea.	Low-water above sea.
		Feet.	*Feet.*
35	On top of water table at southeast corner of engine-room of elevator at Fulton, Ill	578.682	559.740
36	On southeast corner of engine bed of water-works at Clinton, Iowa	578.838	559.150
37	On door-sill in front of south jamb of south door of Harper's old store at Albany, Ill	576.872	....
38	On center of stone window-sill in foundation on north side of Hyman's warehouse at Comanche, Iowa	580.844	556.530
39	On corner of first course of stone above foundation in front of west jamb of door on north side of stone warehouse at Cordova, Ill	565.355	554.620
40	On window-sill of south window in foundation of warehouse on northwest corner of Main and Cherry streets at Port Byron, Ill	570.436	....
41	Zero of United States water gauge on Rock Island and Davenport bridge	533.761	533.761
42	On northwest corner of stone foundation of smoke-stack of saw-mill at Buffalo, Iowa	546.064	530.360
43	On door-step of post office at Fairport, Iowa	550.102	526.730
44	On stone bed of pump cylinder of water-works at Muscatine, Iowa	540.904	523.606
45	On southeast corner of foundation of chimney of saw-mill at Port Louisa, Iowa	538.171	519.180
46	On ring-bolt on large stone at southwest corner of F. C. Bell's warehouse, New Boston	53[illegible].016	517.630
47	On stone door-step of west door in Main street of brick building at northwest corner of Main and Second streets, Keithsburg, Ill	533.157	516.890
48	On west side of raised portion of door-step of Journal printing-office, Oquawka, Iowa	527.507	509.820
49	On cross-cut in top of coping on north side of east abutment of railroad bridge, Burlington, Iowa	535.979	505.089
50	On head of railroad spike in east face of southeast corner of stone foundation of Union warehouse at Fort Madison, Iowa	516.356	496.557
51	On cross-cut in top of stone post 8 inches square, 2 inches above ground, 500 feet below water-tank of Chicago, Burlington and Quincy Railroad at Montrose, Iowa, Station F of canal survey	506.176	493.583
52	On spike driven in wall at upper end of front of Brown's warehouse at Keokuk, Iowa; high-water of 1851	493.082	472.330
53	On 5 nails driven in top of snubbing post near southeast corner of Cunningham's warehouse at Alexandria, Mo	491.672	469.787
54	On elm, 1,200 feet below mouth of Fox River, at Gregory's Landing, Mo	479.556	466.805
55	On northeast corner Carnegy's warehouse, Canton, Mo	475.484	461.288
56	On top of eye-bolt of mooring-ring at southwest corner of K. N. L. Packet Company's warehouse, La Grange, Mo	473.470	....
57	On spike on northeast corner of abutment at west end of railroad bridge eleventh joint from top of parapet at Quincy, Ill	471.363	453.179
58	On northeast corner of top of abutment at Missouri end of railroad bridge at Hannibal, Mo	475.337	444.547
59	On pecan tree near right bank of river opposite head of Gilbert's Island	449.989	439.062
60	On elm tree 15 inches diameter, 50 feet from right bank of river, 1,000 feet above Magee's house at Mundy's Landing, Mo	449.009	437.820
61	On top of stone foundation at southwest corner of engine-room of Louisiana Lumber Company's mill at Louisiana, Mo	455.547	430.970
62	On lower southeast corner of stone door-sill of Vinegar Factory at upper end of Clarksville, Mo	446.997	426.930
63	High water-mark on upper warehouse, Falmouth, Mo	441.440	417.640
64	On elm tree, 24 inches diameter, on right bank of river 800 feet below lower house at Sterling, Mo	431.440	415.740
65	On 5 nails driven in top of snubbing post, 51 feet in front of Vance & Harvey's store at Cap Au Gris, Mo	431.438	411.040
66	On northeast corner of northeast corner-stone of first derrick foundation below steamboat landing, Grafton, Ill	415.188	399.440

Drainage areas of tributaries of the Mississippi above the Missouri River.

Number.	Localities.	Right or left bank.	Square miles.
1	Upper Mississippi (above the Minnesota)	......	19,903
2	Minnesota	R.	12,119
3	Saint Croix	L.	7,146
4	Trimbelle, Isabelle, and Rush	L.	379
5	Cannon	R.	1,600
6	Chippewa	L.	9,530
7	Zumbro	R.	1,664
8	Whitewater and Indian Creek	R.	521
9	Buffalo, Eagle, and Trempealeau	L.	1,42[illegible]
10	Black and La Crosse	L.	3,3[illegible]
11	Root	R.	1,82[illegible]
12	Upper Iowa	R.	1,37[illegible]
13	Yellow	R.	652
14	Wisconsin	L.	11,6[illegible]
15	Turkey	R.	1,59[illegible]
16	Galena	L.	1,8[illegible]
17	Maquoketa	R.	2,2[illegible]
18	Wapsipinicon	R.	2,9[illegible]
19	Rock	L.	9,6[illegible]
20	Iowa	R.	12,[illegible]
21	Edwards	L.	[illegible]
22	Henderson	L.	1,[illegible]
23	Skunk	R.	4,7[illegible]
24	Des Moines	R.	13,[illegible]
25	Fabius (and two creeks)	R.	3,[illegible]
26	Salt	R.	2,[illegible]
27	Cuivre (and two creeks)	R.	1,[illegible]
28	Illinois	L.	27,[illegible]
	Total drainage area, square miles	......	159,[illegible]

Table of distances by low-water channel, high and low water elevations above the sea, and slopes, from Saint Paul to mouth of Illinois River.

Locality.	Distance between points.	Distance from Saint Paul.	Low water (1864), elevation above sea.	Slope in feet per mile between points.	High-water. Year.	High-water. Elevation above sea.	Range.
	Miles.	*Miles.*	*Feet.*			*Feet.*	*Feet.*
Saint Paul Bridge	......		678.00	......	1850	697.72	19.72
Newport	8.50	8.50	673.51	0.528	1850	691.89	18.38
Hastings	18.50	27.00	663.75	.527	1870	682.51	18.76
Diamond Bluff	15.75	42.75	659.67	.258	......	......	......
Red Wing	9.50	52.25	657.75	.202	1870	674.35	16.60
Waconta	7.00	59.25	656.40	.138	1870	670.29	13.89
Reed's Landing	24.50	83.75	656.30	.000	......	......	......
Wabasha	2.75	86.50	654.85	.527	1870	666.90	12.05
Alma	9.00	95.50	649.48	.597	1870	662.10	12.62
Minneiska	10.00	105.50	643.19	.629	......	......	......
Fountain City	11.75	117.25	637.41	.491	......	......	......
Winona	7.50	124.75	632.44	.663	......	......	......
Trempealeau	12.75	137.50	627.10	.419	1869	643.07	15.97
Dresbach	10.50	148.00	623.39	.346	......	......	......
La Crosse	8.00	156.00	621.23	.280	1870	636.70	15.47
Brownsville	10.00	166.00	615.55	.560	1870	631.31	15.76
Genoa	12.75	178.75	610.28	.447	......	......	......
Victory	8.25	187.00	608.64	.490	......	......	......
Lansing	11.75	198.75	605.49	.260	......	......	......
Lynxville	12.50	211.25	601.76	.286	1870	622.04	20.28
Allamakee	9.60	220.85	598.50	.333	......	......	......
Prairie du Chien	6.17	227.02	597.57	.168	......	......	......
Clayton	11.97	238.99	594.67	.239	1870	614.98	20.31
Glen Haven	6.10	245.09	593.00	.273	......	......	......
Cassville	11.25	256.34	588.24	.390	1870	608.58	20.34
Waupeton	7.10	263.44	585.59	.425	......	......	......

Table of distances by low-water channel, &c.—Continued.

Locality.	Distance between points.	Distance from Saint Paul.	Low-water (1864), elevation above sea.	Slope in feet per mile between points.	High-water. Year.	High-water. Elevation above sea.	Range.
	Miles.	*Miles.*	*Feet.*			*Feet.*	*Feet.*
Wells' Landing	7.88	271.32	583.10	.316	1870	603.17	20.07
Dubuque	13.19	284.51	578.22	.370	1871	599.95	21.73
Deadman's Bar	10.61	295.12	574.92	.316	....	....	....
Bellevue	12.37	307.49	571.12	.307	....	....	....
Golden's	5.67	313.16	569.10	.344	....	....	....
Savanna	14.83	327.99	564.37	.258	....	....	....
Fulton	18.12	346.11	559.74	.356	....	....	....
Comanche	8.50	354.61	556.50	.376	1851	580.37	23.87
Cordova	9.00	363.61	554.60	.205	....	....	....
Le Claire	5.25	368.86	554.00	.127	1870	567.00	13.00
Rock Island	14.75	383.61	533.77	1.372	1880	552.17	18.40
Buffalo	11.00	394.61	530.36	.309	1851	547.53	17.17
Fairport	12.63	407.24	526.72	.290	1874	544.14	17.42
Muscatine	8.38	415.62	523.60	.250	1874	538.58	14.98
Port Louisa	13.50	429.12	519.81	.356	....	....	....
New Boston	8.25	437.37	517.63	.264	1874	531.02	13.39
Keithsburg	5.50	442,87	516.80	.136	1851	532.16	15.36
Oquawka	13.25	456.12	509.82	.533	....	....	....
Kaintucks	5.12	461.24	507.60	.425	....	....	....
Burlington	6.44	467.68	505.10	....	1870	520.10	15.00
Dallas	12.34	480.02	500.99	.440	....	....	....
Fort Madison	8.84	488.86	496.70	.205	....	....	....
Montrose	8.85	497.71	494.50	.256	....	....	....
Keokuk	11.12	508.83	472.33	2.009	1851	492.62	20.29
Warsaw	4.04	512.87	469.70	.600	1851	491.82	22.12
Dodd's	10.60	523.47	464.66	.493	....	....	....
Tully Island	4.28	527.75	462.71	.456	....	....	....
La Grange	8.14	535.89	466.53	.759	....	....	....
Quincy Bridge	8.71	544.60	453.80	.399	1851	474.86	21.06
Hannibal	18.81	563.41	444.95	.452	1851	466.30	21.35
Saverton	6.87	570.28	441.30	.376	....	....	....
Mundy's Landing	9.38	579.66	437.78	.580	....	....	....
Louisiana Bridge	11.87	591.58	430.97	.493	1851	451.47	20.50
Clarksville	9.43	600.96	426.93	.428	1851	449.94	23.01
Slim Island (foot)	10.84	611.80	420.90	.510	....	....	....
Falmouth	7.78	619.58	417.64	.483	1858	441.39	23.75
Sterling	4.11	623.69	415.74	.462	....	....	....
Turner's Landing	4.45	628.14	413.49	.505	....	....	....
Cap Au Gris	5.36	633.50	411.04	.462	1858	433.30	22.26
Barrack Island	6.54	640.04	407.83	.491	....	....	....
Phelps' Landing	10.56	650.60	402.54	.501	....	....	....
Grafton	6.13	656.73	399.44	.505	....	....	....

	Feet.
Total fall Saint Paul to Grafton	278.56
Average fall per mile	.424

The high-water of June, 1880, is the highest known in the Upper Mississippi River, but no record of this has as yet been made except at Rock Island. A map of the Upper Mississippi River from Saint Paul to the mouth of the Illinois River (excepting Des Moines Rapids), in 83 sheets, forms a part of this report, as also: 1. Profile of the Mississippi River from Saint Paul to Grafton. 2. Sheet of platted gauge readings.

[NOTE.—The sheets above mentioned have already been forwarded in installments to the Chief of Engineers.]

Upon the map are marked all instrument stations, bench marks, &c.

The soundings and water surfaces are recorded as taken with the dates at which they were observed.

No reduction to low-water is made, except by the drawn curves of 3, 4½, and 6 feet below low-water of 1864.

List of general maps, Saint Paul, Minn., to Grafton, Ill.

Number.	Description.	Island No.—	To Island No.—	Scale.	Date of survey.	Assistant in charge.	Bars and obstructions.
1	Saint Paul to foot of Pig's Eye Island.	...	1	1–4800	May, 1879	J. L. Gillespie.	Frenchman's, Pig's Eye.
2	Foot Pig's Eye Island to above Newport.	1	3	1–4800	June, 1879	....do	Kaposia, Upper and Lower Red Rock.
3	Above Newport to head Grey Cloud Island.	4	9	1–4800	June, 1879	....do	Newport, Merrimac, Robinson.
4	Head Grey Cloud Island to Grey Cloud.	9	13	1–4800	June, 1879	....do	Pine Bend, Grey Cloud Island, and rocks.
5	Grey Cloud to Nininger	14	18	1–4800	June, 1879	....do	Boulanger, Nininger.
6	Nininger to Point Douglass	18	19	1–4800	June, 1879	....do	Nininger, Hastings.
7	Point Douglass to Prescott	19	19	1–4800	June, 1879	....do	Prescott Island.
8	Prescott to 7 miles below	19	22	1–9600	1878	F. Terry	Prescott Island, Smith's.
9	Seven miles below Prescott to Trenton.	22	23	1–9600	1878	....do	Diamond Bluff, rocks.
10	Trenton to below Waconta, Lake Pepin.	24	28	1–9600	1878	....do	Waconta, head Lake Pepin.
11	Below Waconta to below Frontenac.	...	...	1–9600	1878	....do	Do.
12	Below Frontenac to above North Pepin.	...	...	1–9600	1878	....do	Do.
13	Above North Pepin to above Wabasha.		29	1–9600	1878	....do	Reed's Landing, Chippewa River.
14	Above Wabasha to above Alma..	30	39	1–9600	1878	....do	Wabasha, Crat's Beef Slough.
15	Above Alma to below Buffalo City	40	48	1–9600	1878	....do	Pine Island, West Netwon.
16	Below Buffalo City to below Chimney Rock.	48	55	1–9600	1878	....do	Minneiska, Mount Vernon, Chimney Rock.
17	Below Chimney Rock to below Fountain City.	55	69	1–9600	1878	....do	Rollingstone, Betsey Slough, Wild's.
18	Below Fountain City to below Homer.	69	75	1–9600	1878	....do	Argo Island, Winona, Homer.
19	Below Homer to above Queen's Bluff.	75	79	1–9600	1878	....do	Trempealeau.
20	Above Queen's Bluff to below Dresbach.	79	98	1–9600	1878	....do	Queen's Bluff, Dakota, Dresbach.
21	Below Dresbach to below La Crosse.	98	109	1–9600	1879	....do	La Crosse, Grand Crossing.
22	Below La Crosse to below Brownsville.	110	117	1–9600	1879	....do	Below Picayune Island, Brownsville.
23	Below Brownsville to above Genoa.	118	125	1–9600	1879	....do	Coon Slough.
24	Above Genoa to Victory	126	135	1–9600	1879	....do	Do.
25	Victory to below De Soto	136	142	1–9600	1879	....do	Below Victory.
26	Below De Soto to below Lansing..	142	148	1–9600	1879	....do	Above Lansing.
27	Below Lansing to above head Crooked Slough.	149	151	1–9600	1879	....do	Above head Crooked Slough.
28	Above head Crooked Slough to Island 163.	152	163	1–9600	1878	F. W. Lehnartz	Head Crooked Slough, Viola.
29	Island 163 to above Prairie du Chien.	163	167	1–9600	1878	....do	Valley Crossing, below Island 164.
30	Above Prairie du Chien to below Wisconsin River.	167	174	1–9600	1878	....do	Foot McGregor Channel.
31	Below Wisconsin River to below Clayton.	175	183	1–9600	1878	....do	Wyalusing, Clayton.
32	Below Clayton to head Cassville Slough.	183	189	1–9600	1878	....do	Cassville Slough.
33	Head Cassville Slough to above Buena Vista.	189	197	1–9600	1878	....do	Foot Cassville Slough.
34	Above Buena Vista to below Findley's.	197	207	1–9600	1878	....do	Waupeton, Hurricane Island.
35	Below Findley's to below head Maquoketa Slough.	207	217	1–9600	1878	....do	Findley's, Specht's, Parson's.
36	Below head Maquoketa Slough to below Dubuque.	217	227	1–9600	1878	....do	Above Eagle Bluff.
37	Below Dubuque to above Gordon's Landing.	227	234	1–9600	1878	....do	Nine-Mile Island.
38	Above Gordon's Landing to below mouth Galena River.	235	242	1–9600	1878	....do	Deadman's, Gordon's.
39	Below mouth Galena River to Bellevue.	242	249	1–6600	1878	M. E. Schmidt.	Bellevue.
40	Below Bellevue to below Sand Prairie.	250	257	1–9600	1878	C. W. Durham.	Sand Prairie.

List of general maps, Saint Paul, Minn., to Grafton, Ill.—Continued.

Number.	Description.	Island No.—	To Island No.—	Scale.	Date of survey.	Assistant in charge.	Bars and obstructions.
41	Below Sand Prairie to Savanna...	257	266	1-9600	1878	....do	Arnold's, Keeler's.
42	Savanna to Island 278	267	278	1-9600	1878	J. P. Allen	Below Dark Slough.
43	Island 279 to below Fulton.......	279	287	1-9600	1878	....do	Elk River.
44	Below Fulton to below Comanche.	287	294	1-9600	1878	....do	Do.
45	Below Comanche to below Cordova.	294	300	1-9600	1878	....do	Adams Island, Cordova.
46	Below Cordova to Le Claire	300	301	1-9600	1878	....do	Do.
47	Le Claire to Rock Island..........	301	307	1-6000	1869	E. F. Hoffman.	Rock Island Rapids.
48	Rock Island to below Horse Island	309	317	1-9600	1878	J. P. Allen	Horse Island Rocks.
49	Below Horse Island to 4 miles below Buffalo.	317	324	1-9600	1878	....do	Above Buffalo.
50	Four miles below Buffalo to below Fairport.	324	328	1-9600	1878	....do	Below Buffalo.
51	Below Fairport to Muscatine.....	329	335	1-9600	1878	....do	Drury's, rocks above Muscatine.
52	Muscatine to Island 343	335	343	1-9600	1878	....do	Do.
53	Island 343 to foot of Turkey Island.	343	351	1-9600	1878	....do	Turkey Island.
54	Foot of Turkey Island to above Keithsburg.	351	355	1-9600	1878	....do	New Boston Rocks.
55	Above Keithsburg to below Keithsburg.	355	361	1-9600	1878	....do	Keithsburg Rocks.
56	Below Keithsburg to above Oquawka.	361	365	1-9600	1878	....do	Above Oquawka.
57	Above Oquawka to Slater's wood-yard.	365	373	1-9600	1878	....do	Island 370.
58	Slater's wood-yard to head Burlington Island.	373	377	1-9600	1878	G. A. Marr....	Rush Chute.
59	Head Burlington Island to foot of same.	377	377	1-9600	1878	....do	Bad River.
60	Foot Burlington Island to below Pontoosac.	377	388	1-9600	1878	....do	Dallas Rocks, &c.
61	Below Pontoosac to below Fort Madison.	388	394	1-9600	1878	....do	Fort Madison and below.
62	Below Fort Madison to Montrose.	394	401	1-9600	1878	....do	Do.
63	Vicinity of Keokuk, Warsaw, and Alexandria.	404	407	1-9600	1878	H. Custer	Warsaw.
64	Vicinity of Gregory's Landing...	407	409	1-9600	1878	....do	Gregory's Landing Rocks.
65	Vicinity of Tully Island..........	410	415	1-9600	1878	....do	Tully Island.
66	Canton to La Grange	416	420	1-9600	1878	....do	Canton, Wyaconda.
67	La Grange to above Quincy.......	420	425	1-9600	1878	....do	Below La Grange.
68	Vicinity of Quincy to above Marion City.	427	434	1-9600	1878	....do	Quincy, Fabius Island.
69	Vicinity of Marion City..........	434	435	1-9600	1878	....do	Do.
70	Below Marion City to above Hannibal.	436	441	1-9600	1878	....do	Armstrong's, Whitney's.
71	Hannibal to above Saverton......	443	445	1-9600	1878	J. H. Morrison	Do.
72	Above Saverton to Gilbert's Island.	445	448	1-9600	1878	F. A. Churchill	Taylor's.
73	Gilbert's Island to below Mundy's Landing.	448	451	1-9600	1878	....do	Gilbert's Island.
74	Below Mundy's Landing to above Louisiana.	450	456	1-9600	1878	J. H. Morrison	Above Scott's Landing.
75	Above Louisiana to Cash Island..	456	459	1-9600	1878	....do	Krider's Bend, Louisiana Bridge.
76	Cash Island to foot Clarksville Island.	459	463	1-9600	1878	....do	Above Clarksville.
77	Foot Clarksville Island to Slim Island.	363	469	1-9600	1878	F. A. Churchill	Slim Island.
78	Slim Island to Hamburg Island	469	480	1-9600	1878	....do	Do.
79	Hamburg Island to foot of Sterling Island.	481	491	1-9600	1878	....do	Westport Chute.
80	Foot of Sterling Island to Sandy Island.	491	498	1-9600	1878	....do	Stag Island.
81	Sandy Island to Cuivre Island...	498	504	1-9600	1878	....do	Sandy Island.
82	Cuivre Island to Dardenne Island	504	514	1-9600	1878	....do	Two Branch Island.
83	Dardenne Island to Grafton (Illinois River).	514	526	1-9600	1878	....do	

Respectfully submitted.

A. MACKENZIE,
Captain of Engineers.

CHIEF OF ENGINEERS, U. S. A.

SURVEY AND EXAMINATION OF THE MISSISSIPPI RIVER BETWEEN BURLINGTON, IOWA, AND MONTROSE, IOWA.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July —, 1880.

GENERAL: I have the honor to present, as an appendix to my annual report, the following "report upon a survey and examination of the Mississippi River between Burlington, Iowa, and Montrose, Iowa (above the mouth of the Illinois River), made in accordance with resolutions of Board of Engineers, on improvement of low-water navigation of Mississippi and Missouri Rivers."

Instructions from the Chief of Engineers, dated August 30, 1878, assigned to Maj. F. U. Farquhar, Corps of Engineers, the surveys and examinations of the Mississippi River, at some point above the mouth of the Illinois River, desired by the Board of Officers, constituted by Special Order No. 71, series of 1878, Headquarters Corps of Engineers, to take into consideration the improvement of the low-water navigation of the Mississippi and Missouri rivers.

The information desired by this Board was as follows:

1st. Transit survey of river banks and water lines at low stages with soundings to cover the entire length of shoals and to show the changes in the same, the character of bed and banks to be carefully noted. Numerous borings should be made on the banks and in the bed to determine the character of material, and carried 20 or 30 feet below the bed, unless rock is sooner reached.

A line of levels down one bank in connection with gauges to determine the river slope at various points and various stages. Permanent bench marks and reference points, which will be safe for many years, should be established.

2d. Determinations of cross-sections at shoalest place and also at a deep-water section in the vicinity. These cross-sections to be repeated for every 5 feet of change in the river height and as much oftener as practicable during one year, their object being to determine all facts connected with the motion and dimensions of sand waves.

3d. Sediment observations at the surface and within 1 foot of the bottom, to be continued throughout a year on the Mississippi and Missouri rivers, at distances above the mouth of the latter sufficient to be out of reach of backwater, also at Saint Louis, Columbus, and up the Ohio, Arkansas, and Red rivers. These observations should determine not only the amount of the sediment, but the proportional quantities referred to at least three standard sizes. Discharge observations to be obtained when practicable, and low-water discharge to be obtained for the Missouri, and for the Mississippi, at Colonel Farquhar's Point, Saint Louis, Columbus, Memphis, and Vicksburg.

It is also desirable that sediment, cross-section, and discharge observations be made in accordance with the above programme on the Cumberland, Tennessee, White, and St. Francis rivers, far enough above their mouths to be out of reach of backwater. These, however, are of secondary importance.

A portion of the Mississippi River between Burlington and Montrose, and extending some 7 miles above Burlington (total length 42 miles) was selected for survey and examination, and the immediate vicinity of Burlington was chosen for special observations. The survey and examination, under immediate charge of Assistant G. A. Marr, was commenced in 1878, and carried on during the following fall and winter, and the spring of 1879. The work of the survey consisted in a triangulation, transit, and level line, the entire distance. The soundings were taken with suf-

ficient detail to locate the bars quite accurately. The level line was connected with water gauges at various points, and readings to the water surface were taken once in a thousand feet. Permanent bench marks were established, and borings were made at several points. Four bars in the vicinity of Burlington were selected for special observations, their outlines and sections being found by leveling. The results of the survey and examinations have been platted on a scale of 1 inch to 400 feet, and are shown in sheets 2, 3, 4, 5, and 6. Two cross-sections were selected in the vicinity of Burlington and used in connection with gaugings of the river. Cross-section No. 1 was sounded 3 times, showing a material change in form, as was expected from the movement of a sand-bar above it.

Cross-section No. 2 was sounded twice, with an interval of 4 months and 6 days, and shows but slight changes. Cross-sections are shown on sheet 8. These sections do not afford much assistance in a study of the movement of sand waves or motion of sand-bars, but taken in connection with the special bars, whose changes were carefully noted, as shown on sheet 2, some idea can be formed of the movement of the particular bars under consideration.

The observations made during the progress of this special survey, as well as information obtained from work on the upper river, and from the best sources now obtainable, indicate that each-bar, being composed of varying materials and influenced by different circumstances, has a rate of motion of its own, these rates varying from 10 to 1,000 feet in a year's time. The hydrographic survey of the 42 miles of river from Henderson Creek to Montrose is in sufficient detail to afford, from comparison with future surveys, quite an accurate estimate of the general movement and changes of the bars included.

Gaugings of the river were made for each change of 1 foot in stage, 7 being taken in cross-section No. 1, and 5 on cross-section No. 2. The results of gaugings are shown on sheet 11. Cross-section No. 2 remained comparatively constant during the entire season, and the gaugings taken on it are probably entitled to more weight than those taken on section No. 1. Sediment observations were made in May and June, 1879, and the results are shown on sheet 12.

The following sheets form a part of this report:

[NOTE.—Sheets 1, 2, 3, 4, 5, 6, 8, 9, 10, are not attached to this report. Sheets 2 (excepting borings and measurement of sand-bars), 3, 4, and 5 form a part of general survey of Mississippi River from Saint Paul to Grafton, and have been forwarded with that series. Sheets 6, 8, 9, 10, and a sheet of borings, &c., are forwarded separately.]

Sheet 1.—Index map of survey.

Sheet 2.—Map No. 1 detailed survey of Mississippi River from 7 miles above Burlington to 2 miles below; shows also borings, movement of sand-bars, &c.

Sheet 3.—Map No. 2, detailed survey from 2 miles below Burlington to foot of island No. 382.

Sheet 4.—Map No. 3, detailed survey from foot of island No. 382 to 2 miles below Fort Madison, Iowa.

Sheet 5.—Map No. 4, detailed survey from 2 miles below Fort Madison to Montrose.

Sheet 6.—Profile of Mississippi River from 7 miles above Burlington to Montrose.

Sheet 7.—Index map showing location of cross-sections 1 and 2, borings near Burlington, sand-bars observed for motion, and gauges.

Sheet 8.—Cross-sections 1 and 2 at different dates.

Sheet 9.—Shows method of sounding and of computing mean depth and area of cross-sections.

Sheet 10.—Shows method of determining and computing quantities entering general equation for velocity, discharge, &c.

Sheet 11.—Results of gaugings, &c., tabulated.

Sheet 12.—Results of sediment observations tabulated.

Sheet 13.—Platted sheet of velocity, discharge, stage, and sediment.

Sheet 14.—Diagram of discharge at Burlington.

There follow some extracts from the report of Assistant G. A. Marr, made September 12, 1879, on methods of observation, computation, &c.

GAUGING.

Method of observing.—Gaugings were made at two places in front of the city of Burlington. The first designated cross-section, No. 1, is opposite the Burlington, Cedar Rapids, and Northern freight depot, the second, called cross-section No. 2, is opposite the foot of Locust street. The two cross-sections were laid out in the same manner as follows:

A base line 200 feet long was carefully measured on the Illinois side of the river and a similar base parallel with and opposite to the first was measured on the Iowa side. The line joining the upper extremities of the 2 bases is called the upper section, and the corresponding line at the lower extremities of the bases is called the lower section. The upper and lower sections are perpendicular to the bases. In making the observations for mean velocity and discharge, a skiff with 10 double floats was anchored 100 feet above the upper section successively at different distances from the base, the distance being so selected as to give the best determination of the variation of the velocity at different points in the width of the river. Observers were stationed at the upper and lower ends of the Illinois base with theodolites pointed across the river so as to mark out the upper and lower sections. A third observer was stationed at a located point on the river bank about 1,000 feet from the base to locate the floats by theodolite readings. Each observer was provided with a telegraph key and sounder, and telegraphic communication was established between them. A fourth observer with a mean time chronometer was stationed near the key at upper base. A double float with the parts joined by a cord of sufficient length to allow the center of the lower one to reach the mid-depth of the river at that point, was dropped from the anchored skiff. As it approached the upper section warning of its approach was given by the observer at upper section tapping the telegraph key twice in quick succession about 20 seconds before the float reached the upper section. As it crossed the section the observer at upper section tapped his key once, the time was noted by the observer at the chronometer, and a reading was taken to the float by the observer whose duty it was to locate it. Similar observations were made when the float crossed the lower section, after which the float was picked up by a skiff stationed below for that purpose. The difference of the observed time of crossing the two sections gives the time required by the float to move 200 feet in a direction parallel to the base, and the theodolite readings determine the distance from the base. Ten floats were sent down from each position of the skiff except in very shoal water where a lesser number was sent. The total number of floats sent from each position of the skiff is called a series.

In the gaugings previous to May 9, 1879, which were all taken on cross-section No. 1, the floats used consisted of a sheet of tin 22 by 11 inches, with pieces 11 inches square hinged to it at its middle point in each side, forming, when ready for use, 2 planes, intersecting at right angles, and so placed in the water that the line of intersection of the planes should be vertical. This lower part of the float was joined by a cord 0.025 inch in diameter to the upper part, which was made by soldering together the bases of two hollow tin cones 6 inches in diameter by 5 inches high. In order to be more easily seen, a flag about 5 inches square was attached to the upper part of the float. In the gaugings made on and after May 9, 5 floats of the form above described were used

in each complete series, and also 5 floats in which a weighted paint-keg, 11 inches high by 11 inches in diameter, was substituted for the tin wings forming the lower part of the float. The cord joining the two parts of this float was tied to two cross-wires, intersecting as nearly as possible in the center of figure of the paint-keg. In the reduction of the gaugings a mean of all the observations of a series which were made with the same kind of floats was adopted, as giving the time required by the float to pass the base. In gaugings where both kinds of floats were used, the entire computation has been made independently for the tin floats and paint-kegs, and the results derived from each are given in the tabulation. Numerous soundings were taken upon each cross-section to determine its area, and levels were taken on each side of the river between the base and the water's edge, to determine the effect which a change of stage has upon the area of the cross-section. The first soundings on cross-section No. 1 were taken early in April, 1879. It being afterwards suspected that considerable changes had taken place in the river bed, the cross-section was resounded early in June, when it was discovered that changes had taken place. The first soundings were used in the computations of gaugings from April 18 to May 9, 1879, inclusive; the June soundings are used in the reduction of gaugings of June 2 and 18, and a mean of the April and June soundings for the gauging of May 26. To determine the slope of the river, gauge-staffs were set up and the difference in the elevations of their zeros ascertained by leveling.

Readings of these staffs were taken in connection with the gaugings. Different combinations of these gauges were made upon different days, the distance between the 2 gauges used for measuring the slope ranging from ½ a mile to 1¼ miles.

Computation.—In the computation of the gaugings the position of the mean of a series of floats was first determined from the readings to the several floats; then the mean velocity given by the series was computed, and from the mean velocities the velocities of different portions of the river, called sections, were obtained. These velocities multiplied by the areas of the sections give the approximate discharges of the sections from which the mean velocity and discharge of the whole river are obtained by the rigorous method given on page 314 of "Humphreys' and Abbot's Report on the Mississippi River," all of which will be treated more in detail below.

Position of floats.—For each cross section a table was constructed giving the distance from the base, of points in the upper and lower sections corresponding to given readings at the station commonly occupied for locating floats.

A mean of all the readings to floats on each section which were to be combined in the reduction was taken, and the distance corresponding to this reading looked out from the table. A mean of the distances to the same series of floats on the upper and lower sections was then taken and assumed as the distance of the series from the base, corresponding to the velocity deduced from that series. These velocities in feet per second were next obtained, by dividing the length of the base by the mean of the observed times of transit past the base.

Division of the river into sections.—The plan first adopted and used in the gaugings of April 18, 19, April 28 and May 2, 1879, for the division of the width of the river into sections, was to assume as many sections as there were series of floats in the gauging, the limits of the sections being midway between the positions of the several series. A profile of the river-bed was plotted from the soundings from which the mean depth of each section was obtained and the observed velocity was assumed as

the mean velocity of the section in which it occurred. This method being found neither convenient nor sufficiently accurate, the following method was adopted for the remaining gaugings.*

Commencing at a point assumed at an arbitrary distance from the Illinois base, for cross-section No. 1, 174 feet, and for cross-section No. 2, 88 feet, the river was divided into sections each 100 feet wide. The river varying somewhat in width with the stage of water, it is evident that the sections contiguous to the shore cannot be assumed as of any constant width, and a profile of the shore was therefore constructed from the levels and the soundings, by means of which profile the width and mean depth corresponding to any stage can be readily obtained. For all sections except the shore sections, a mean of all the soundings on each section reduced to zero stage was taken as the mean depth of the section at that stage and a table formed for each cross-section giving these mean depths.

The mean depth corresponding to any stage of the river is found by adding the figures representing the stage to the tabular number, and since the width of the section is 100 feet, the area is found by moving the decimal point two places to the right. The mean-velocities of the 100 feet sections were taken from a curve platted by using as abscissas the distances from the Illinois base and as ordinates the observed velocities.

Solution of the final equation.—The formula given by Humphreys and Abbot for determining the mean velocity of the whole river is

$$\Sigma\, a\, (v) + \Sigma\, (a\, \tfrac{1}{12}\, b^{\frac{1}{2}}\, v^{\frac{1}{2}}) = \Sigma\, (a\, V^{\frac{1}{2}}\, D).$$

in which

$$b = \frac{1.69}{\sqrt{D + 1.5}},$$

D being the depth of the river at any point.

Values of the quantity $\tfrac{1}{12}\, b^{\frac{1}{2}}$ have been computed for values of D from 0 to 30 feet and have been tabulated. The values of the coefficients used in the computations are obtained from this table.

The equation for determining $v^{\frac{1}{2}}$ becomes by dividing by $\Sigma\, a$

$$v + \frac{\Sigma\, (a\, \tfrac{1}{12}\, b^{\frac{1}{2}})}{\Sigma\, a}\, v^{\frac{1}{2}} = \frac{\Sigma\, (a\, V^{\frac{1}{2}}\, D)}{\Sigma\, a}$$

Which is a quadratic equation of the form

$$x^2 + p\, x = q$$

which latter may be solved by putting

$$m \sin M = \sqrt{q}$$
$$m \cos M = \tfrac{1}{2}\, p$$

when the value of x becomes

$$x = -m \cos M \pm m.$$

In the actual application of the formula the positive sign of "m" is used for the reason given on page 314 of Humphreys and Abbot. In the computation of the gaugings the difference of the numbers cos M and m was obtained by the use of "Wittstien's subtraction logarithms." The solution of the above equation determines the square root of the

*The gaugings of April 18, 19, April 28 and May 2, above mentioned, were afterwards recomputed and platted according to method described below, and only the results of this recomputation are given on accompanying sheets.

mean velocity of the whole river at the particular cross-section under consideration. The mean velocity multiplied by the area of the cross-section gives the discharge per second.

General remarks.—Cross-section No. 2 is much better adapted for successful gaugings than cross-section No. 1, and the results obtained from it are entitled to greater confidence than those from No. 1. A sand-bar above section No. 1 kept moving down until it encroached upon the section before the last gauging was taken. At section No. 2 there was no perceptible change.

SEDIMENT OBSERVATIONS.

Sediment observations were made at Burlington, Iowa, during the months of April, May, and June, 1879, to ascertain the amount of sediment held in suspension by the water of the Mississippi River at that point. . The water was taken from the river in a sediment measure constructed especially for this survey at Rock Island Arsenal. The measure consists of a hollow steel cylinder closed at the top and bottom by fixed brass plugs, the top plug being provided with an opening closed by a conical valve which is held firmly to its seat by a spiral spring, and by means of a cord attached is opened as desired. By means of brass clamps the measure may be attached to a pole and lowered to any depth desired.

The water was taken at depths of 1 and 12 feet below the surface at a point where the river was 13 feet deep. The amount of water obtained at each observation was equal to the capacity of the measure, which was found to be 2,375 grams.

The water was emptied into glass jars and allowed to settle. It was at first intended to determine the size of the particles composing the sediment, and a glass micrometer and a powerful microscope were procured for that purpose, but the operation was found to be unsatisfactory on account of the difficulty of separating the sediment from the filter-papers upon which it was deposited without mingling with it particles of the paper. The water, having been allowed to settle a given time, was siphoned off, except about half an inch in the bottom of each jar. The siphoned water was placed in a new jar for further examination, and the residual water, after being thoroughly shaken, was filtered through a pair of filter-papers, which had previously been carefully balanced, so as to be of exactly the same weight. After the filtration, the papers were dried, and the difference in weight was adopted as the weight of the sediment. The above process was repeated until no deposit was perceptible. It was found that sand and the coarser detritus would settle in about 15 minutes, all except clay would settle in 24 hours, and clay in about 100 hours, although in some cases the water would retain a milky appearance for several weeks. The proportion of sediment to water is so small that a long series of observations would be necessary to give definite data.

BORINGS.

Borings were made with a 2-inch auger having a stem of gas-pipe, to which joints were added as the boring progressed. Great difficulty was experienced in boring under water, owing to the filling in of fine sand and mud, so that it was found necessary to first drive a gas-pipe shaft, pump it out, and bore inside of it. The blade of the auger was also inclosed

in a sheet-iron casing in order to prevent the water from washing off the material as the auger was drawn up. The results of the various borings are shown on sheet 2.

Very respectfully, your most obedient servant,

A. MACKENZIE,
Captain of Engineers.

CHIEF OF ENGINEERS, U. S. A.

S 4.

IMPROVEMENT OF THE MISSISSIPPI RIVER FROM LA CROSSE, WISCONSIN, TO MOUTH OF ROOT RIVER.

No work was executed under this appropriation during the past year other than frequent examinations of the locality. The closing dams built in 1878 have settled slightly, but they have well answered the purpose for which they were built in holding the main channel of the river along the city front. The channel in the vicinity of La Crosse, which for several years was very changeable and troublesome, owing to the movement of large bodies of sand caused by closing the chute to the east of Minnesota Island, has now had time to regulate itself, and no trouble is anticipated in this immediate vicinity during the present season.

ABSTRACT OF APPROPRIATION.

By act approved June 18, 1878	$12,500

No further appropriation is asked for.

Money statement.

July 1, 1879, amount available	$782 [illegible]
July 1, 1880, amount expended during fiscal year	782 [illegible]

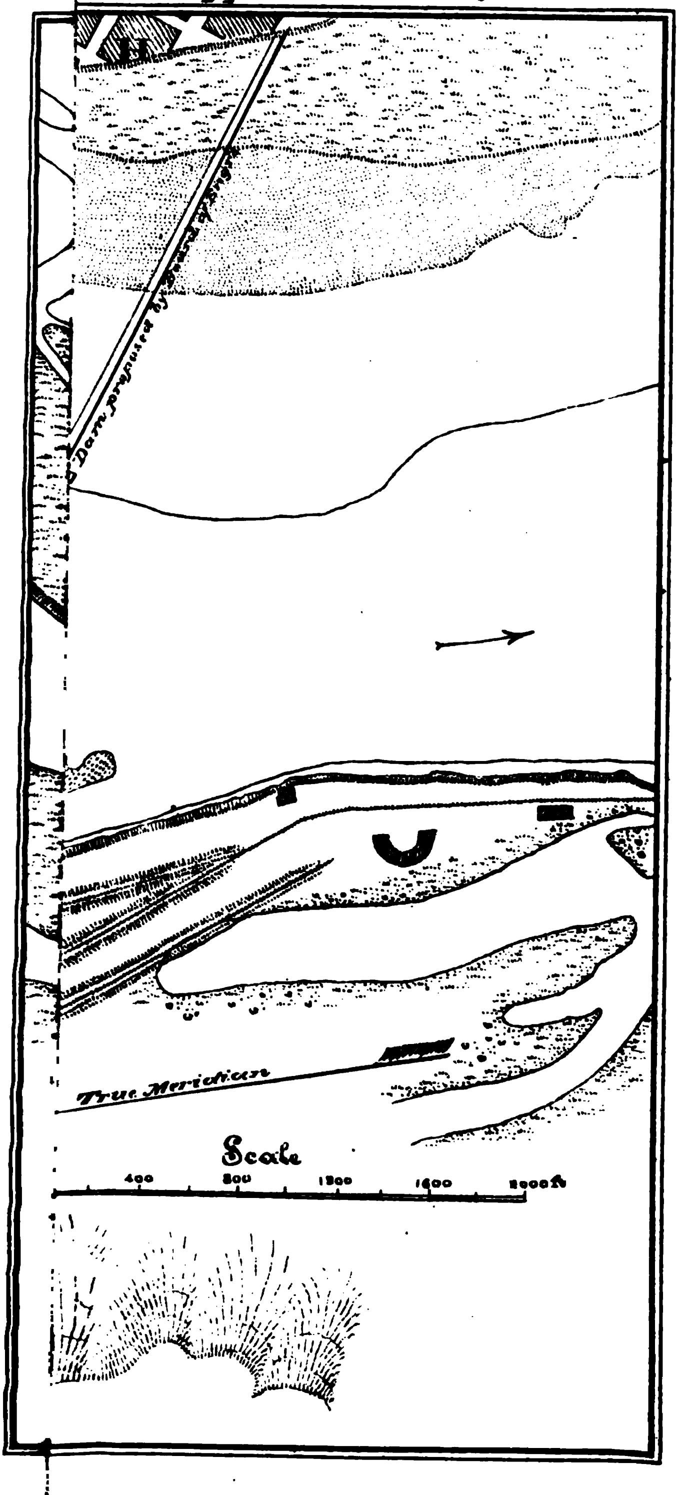
S 5.

REMOVAL OF BAR IN THE MISSISSIPPI RIVER, OPPOSITE DUBUQUE, IOWA.

A project for this work was presented in February, 1876 (Report of Chief of Engineers, Part I, page 696). A modified project, contemplating the removal of the bar by dredging, was approved June 20, 1877 (Report of Chief of Engineers, Part I, page 525). On July 2, 1878, Major Farquhar, in his annual report, submitted a new project for dredging, changing former estimates. In May, 1879, a Board of Engineers submitted a report on Dubuque Harbor, from which the following extract is taken:

The following plan is proposed for the permanent improvement of the harbor: To prevent the reforming of the bar it is proposed to diminish the present low-water cross-section of the river at the landing by constructing two low spur dams on the Dunleith shore, as shown on the tracing hereto attached, rising only a foot above low-water, and extending out to the 3-foot curve at low-water, or further if found necessary. The effect of these spurs on the opposite shore should be carefully watched, and no more contraction should be produced than is necessary to secure the desired effect. The cost of the spurs is estimated at $12,668; but, as the dredging already

River opposite DUBUQUE. Ia.



nearly completed has secured easy access to the landing, and as for two years the dredged space has shown little or no tendency to fill up, although, indeed, there have been no marked high-water periods in this time, it is not proposed to begin construction until the present dredged area shows signs of filling up, when the work should be done without delay.

The construction of the spurs will force the current against the bar and Dubuque shore, but the shore below the bar is already protected by stone, either loose or in paving; hence, any serious cutting of it is not anticipated. The spurs may cause a slight shoaling at the Dunleith Ferry Landing, but the cost, should it be necessary, of a short causeway 200 to 300 feet in length to the new shore-line would be very small. As the bar is now so far removed as to meet the present requirements of commerce, it is proposed to discontinue dredging, and the available appropriation can be retained to commence the proposed spurs. In case there should be no filling up in the next high-water, the dredging should be continued in accordance with the recommendation of Maj. F. U. Farquhar, in his report of July 2, 1878.

As recommended by the Board, an examination was made August 24, 1879, and, as no filling was apparent, the balance on hand was expended in dredging. The details and present condition of work are shown in appended report of M. Meigs, United States civil engineer.

To carry out the existing project, the work remaining to be done is to construct the spur dams from the Illinois shore and continue dredging on the bar, but as there is a possible danger that the channel may leave the draw span, and as there is also a probability that a large portion of the material from which the bar is formed comes from the caving island banks above the bridge, I propose before doing this work to make a thorough low-water examination of the channels and shores above the railroad bridge. The appropriation of June 14, 1880, will be expended for dredging and the commencement of spur dams, unless it appears that the work above referred to is of greater importance. To carry out the project of the Board of Engineers' construction of spur dams is estimated to cost $12,668, and to complete the dredging as estimated by Major Farquhar, in his report of July 2, 1878, will cost $9,102.03, or a total of $21,770.03.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$15,000
By act approved June 18, 1878	10,000
By act approved March 3, 1879	4,000
By act approved June 14, 1880	7,000
Total	36,000

Money statement.

July 1, 1879, amount available	$3,995 76	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$10,995 76
July 1, 1880, amount expended during fiscal year		3,995 13
July 1, 1880, amount available		7,000 63
Amount (estimated) required for completion of existing project		14,770 03
Amount that can be profitably expended in fiscal year ending June 30, 1882.		14,770 03

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1880.

CAPTAIN: I have the honor to submit my report on the "Removal of a bar in the Missippi River opposite Dubuque, Iowa," for the fiscal year ending June 30, 1880. An examination of Dubuque Bar made August 24, 1879, after the subsidence of high-water, showed no change of importance subsequent to the completion of dredging operations

in 1878. A few patches that had been left from 0.1 to 0.3 of a foot above grade were still in place; in a few spots the bottom had been raised 0.1 or 0.2 of a foot; in some others deepened the same amount; there was no filling up that could be discovered. The dredging was therefore continued according to the plan previously pursued, and as recommended in the report of the Board of Engineers convened at Dubuque May 19, 1879. The accompanying sketch shows the areas dredged in different years and the present position of the bar.

The work already performed has been of great benefit to the shipping interests of Dubuque, and has proved satisfactory to steamboat men.

The excavation carried on in 18?0 was in the upper and heavier portion of the bar. The grade was 4¼ feet below low-water, being the same as in previous work, (1878,) and, if the work is carried further up stream, the excavation will be in sand averaging 5 feet above grade, and consequently expensive.

The work was done under agreement with H. S. Brown & Co., of Hamilton, Ill. But two offers were made, that of Brown & Co., and by Whitney & Son, of Keokuk, Iowa. Both bid the same price, 17 cents per cubic yard, and the work was given to Brown & Co., as they owned the only idle dredge on the river. The appropriation ran out before the cleaning up was quite finished, and a small patch was left 2 feet above grade, but it will probably wash down nearly even with the rest of the bottom. I would suggest that no further work be done until a survey at low-water shall have shown what the tendency of the bar may be either to fill up or wash away.

Summary of work to date.

Items.	Cubic yards
Dredged during year ending June 30, 1878	39,36
Dredged during year ending June 30, 1879	37,02
Dredged during year ending June 30, 1880	19,57
Total	85,[illegible]

Cost of dredging 19,573.24 *cubic yards at Dubuque, Iowa.*

Items.	Cost per cubic yard.	Total
19,573.24 cubic yards dredged and removed	$0 17	$3,327 [illegible]
Superintendence and office expenses	0 03	667 [illegible]
Total cost	0 20	3,995 [illegible]

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

S 6.

IMPROVEMENT OF ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

The original project for this work was presented in 1866, and was to make cuts through the various chains of rock, giving an available depth at extreme low-water of 4 feet and a channel width of 200 feet. The work remaining July 1, 1879, to complete the existing project, was to remove some patches of rock at Saint Louis chain; to make a thorough examination of the channel and remove any projecting points of rock, if such were found; to dredge out all loose rock and bowlders which had been carried into the channel by ice; and to establish and maintain a system of channel marks.

The very small appropriation of March 3, 1879, only permitted of the blasting of the patches of rock at Saint Louis chain and the placing in position of a few experimental buoys. The details of the past season's work, together with methods used, are fully given in the annual report of Assistant Engineer E. F. Hoffmann, who has been in local charge of this work from its commencement.

The establishment of buoys on the rapids is difficult, but their necessity is sufficiently great to justify a trial of various forms until the one is found which best resists the blows received at certain stages from steamboats and rafts.

These buoys, once established, should be carefully maintained; and to do this will require the services of a small steamboat which, it is estimated, will cost about $1,200. In reply to a resolution of the House of Representatives, a report, dated March 15, 1880, was submitted, giving a brief history of the Rock Island Rapids improvement, with reasons and estimates for increasing the width of channel to 400 feet. (House Ex. Doc. 67, Forty-sixth Congress, second session.)

The work projected for this fiscal year is to thoroughly examine the cuts through the various chains, dredge out loose rock, and remove any projecting points, and establish channel marks for the aid of navigation. As much of this work will be carried out as the $8,000 appropriated by act of June 14, 1880, will permit. At the beginning of the last fiscal year it was estimated that an appropriation of $12,000 would complete the existing project, and it would have done so, but the reduction of this amount to $8,000 will carry a portion of the work into the fiscal year ending June 30, 1882, and increase its cost materially. I now estimate that an additional appropriation of $8,000 will be needed to complete the existing project and maintain buoys and channel marks.

ABSTRACT OF APPROPRIATIONS.

By act approved June 23, 1866	$100,000
By act approved March 2, 1867	200,000
By allotment from appropriation of July 25, 1868	156,000
By allotment from appropriation of April 10, 1869	133,650
By act approved July 11, 1870	150,000
By act approved March 3, 1871	150,000
By act approved June 10, 1872	50,000
By act approved March 3, 1873	50,000
By act approved June 23, 1874	50,000
By act approved March 3, 1875	50,000
By act approved August 14, 1876	25,000
By act approved June 18, 1878	30,000
By act approved March 3, 1879	6,000
By act approved June 14, 1880	8,000
Total	1,158,650

Money statement.

uly 1, 1879, amount available	$9,176 93	
mount appropriated by act approved June 14, 1880	8,000 00	
		17,176 93
ıly 1, 1880, amount expended during fiscal year		7,742 72
ıly 1, 1880, amount available		9,434 21
nount (estimated) required for completion of existing project		8,000 00
nount that can be profitably expended in fiscal year ending June 30, 1882.		8,000 00

REPORT OF MR. E. F. HOFFMAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1880.

CAPTAIN: I have the honor to submit my report of operations for the "Improvement of the Rock Island Rapids" for the fiscal year ending June 30, 1880.

According to the approved project it was proposed to excavate at Saint Louis chain several patches of rock which encroached upon the channel. On July 6 the small steamer Irene towed the steam-drill scow and quarter boat to Saint Louis chain. The work of blasting with dynamite was begun August 4, 1879, and the result is given in the following table:

Month.	Working days.	Holes drilled.	Depth of holes.	Diameter of holes.	Running feet.	Area covered.	Average excavation.	Amount estimated from hydrographic map.
	Number.	*Number.*	*Feet.*	*Inches.*		*Sq. ft.*	*Feet.*	*Cub. yds.*
August	22	226	3 to 4	3½	793	6,350	2.5	58
September	23	218	4 to 5	3½	981	7,148	2.53	[illegible]
October	16	109	3 to 4	3½	384	2,370	2.90	[illegible]

The total amount of rock broken is 1,513 cubic yards; 286 pounds No. 1, and 800 pounds No. 2 dynamite were used, averaging 1.96 pounds to each drill-hole, of which one-third was No. 1 and two-thirds No. 2. An average of 0.72 pound dynamite to 1 cubic yard of rock was required. The cost per cubic yard was $3.12. The work was much interfered with by passing steamers and rafts, as the plant had to be frequently moved out of their way.

Several charges were fired simultaneously, the average number of connected charges being five, but from twelve to fourteen charges were sometimes exploded at once when the formation of the river bed made it desirable. A Smith magneto-electric battery was chiefly used for firing the charges, and a friction electric battery also did good service. For testing the connection a galvanometer was procured.

The dredging of the broken rock at Saint Louis chain should be performed during the coming season, and it is respectfully recommended that a dredge for this purpose be hired by the day. The above-mentioned work is the first which has been solely executed by subaqueous blasting during the progress of this improvement, and it will be of interest to know if knobs or points of rock have been left above grade, in which case the steam drill will have to be used before the places are dredged, and for this reason the hire of a dredge by the day is preferable. A sum of $3,000 will be sufficient to dredge the improved channel at Saint Louis chain and to do as much subaqueous blasting as may be necessary for removing points found to be above grade.

The steam drill was also used during the season in breaking up pieces of rock which had been carried by ice into the cuts at Smith's, Campbell's, and Duck Creek chains. Orders were received from you to place buoys of different shape at certain places on the rapids, where they could be tried with reference to serving as guides to navigation, and to withstanding collisions with passing steamers and rafts. Two of these trial buoys were made of timber 12 inches square and 12 feet long, fastened to a ring-bolt let into the rocky bottom by a ½-inch chain. Two other buoys were pear-shaped, the large end 22 inches diameter, the small end 8 inches, and 8 feet in length; through the axis a hole 3 inches diameter was bored, and a conical hole cut out of the top of the buoys for the purpose of receiving a cast-iron conical hollow piece with a bar of wrought iron around which the chain is fastened which leads to the ring-bolt inserted in the river bottom. The slack of the chain lies alongside of the holding chain in the interior of the buoy, and the length of the chain can be regulated at pleasure by removing the cast-iron cone. During the winter of 1879–1880 eleven new buoys were constructed, six of the pear-shaped pattern and five spar buoys. The latter were provided with an extra weight of 60 pounds attached to the chain, which at low-water rests on the bottom, and at high-water acts as a compensating spring when the buoy pulls too strong on the ring-bolt.

All the buoys were placed in position between March 28 and April 1, 1880. The accompanying sketch shows their location. Additional buoys will be placed as soon as a lower stage of water permits. The anchoring of the buoys on some of the most difficult places has met with general approval from steamboat men, and it is of much im-

portance to navigation that the plan of buoying the channel be adhered to, and that beacons or landmarks be established for the same purpose.

It is necessary to remove and store away the buoys when ice begins running, and to replace them in the spring. Rafts and steamboats sometimes displace them, and in such cases they should be promptly restored.

For accomplishing this work, and for other purposes, the use of a small steamer on the rapids is indispensable, which can tow the steam-drill scow or a smaller flat-boat provided with conveniences for drilling by hand. Such a steamer could be built for $1,200, and its construction is most respectfully recommended. A survey of the cuts through the various chains is quite necessary for ascertaining what obstructions have been brought into them by ice during the past nine years.

The sounding machine belonging to this improvement is provided with an adjustable rake by means of which small objects on the river bottom may be found and located.

To make the survey the hire of a small steamboat from two to three weeks will be necessary for towing the rake. The notes of the survey can be plotted during the winter so as to be used when another appropriation gives the means of dredging over the entire improved channel of the river.

SUMMARY FOR FISCAL YEAR ENDING JUNE 30, 1880.

Blasting 1,513 cubic yards of rock at Saint Louis chain, at $3.12 per cubic yard	$4,720 56
Removing obstructions washed in by ice at Smith's, Campbell's, and Duck Creek chains	1,675 00
Constructing and establishing buoys	1,347 16
Total expended	7,742 66

Very respectfully, your obedient servant,

E. F. HOFFMANN,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

SPECIAL REPORT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., March 15, 1880.

GENERAL: I have the honor to acknowledge the receipt of a letter from your office, dated March 9, 1880, containing a resolution of the House of Representatives calling for certain maps and reports in reference to a proposed widening of the Rock Island Rapids.

The accompanying map, which shows the present 200-foot channel and the work required for increasing this width to 400 feet, was prepared last winter, but as yet no reports on the subject have been made. I would therefore submit the following:

The Rock Island or Upper Rapids of the Mississippi River extend from Le Claire, Iowa, to Rock Island, Ill., a distance of 14 miles. The river over this reach consists of a succession of deep pools separated by chains of rocks, through which the water, in the course of centuries, has cut irregular channels.

The fall from the head to the foot of the rapids is about 20 feet, giving a velocity of current of from 2 to 10 feet per second at the shoal places.

Previous to improvement the rapids could not be passed by the larger class of steamboats at a 2-foot stage, and at medium stages boats drawing from 3 to 4 feet could only pass on calm days and by using extreme caution.

Congress caused a survey and report on the improvement of the rapids to be made in 1866.

In 1867 the work of excavation was commenced, in accordance with the approved plan, which was to give a channel over the chains 200 feet in width, with a depth of 4 feet below low-water of 1864. From 1867 to 1879, inclusive, $1,150,650 were appropriated, for which sum about 90,000 cubic yards have been removed, virtually completing the above-mentioned plan.

The work already accomplished has greatly benefited navigation, but still certain difficulties are met with.

1. The channel is so crooked that it is not practicable in its present condition to provide a system of lights, and the navigation of the rapids is suspended during the night.

2. The width of 200 feet is not sufficient to admit of 2 boats with barges passing each other, so that either the ascending or descending boat must wait in one of the deep pools until the other has passed through a cut.

3. A fresh breeze, acting against the very long and high Mississippi steamers, endangers, and a strong wind prohibits, navigation through the narrow channels.

4. A large steamer ascending the rapids through the comparatively narrow 200-foot channels draws down the water to such an extent as to materially reduce the depth in the cuts, so that a 4-foot channel is not really available at all parts of the rapids during a low-water stage of the river.

The most available plan that can be suggested for overcoming these difficulties is, as shown on the accompanying map, to widen the present cuts, giving a new channel 400 feet in width. By this widening, the second and third difficulties would be done away with, the fourth would be greatly reduced, and by so straightening the channel as to obtain long reaches, lights could be established which would overcome the first difficulty.

To increase the width of the channel to 400 feet, giving a depth of 4½ feet below low-water, which will insure a grade as low as that of the present cut, will require the removal of 209,811 cubic yards of rock, and will cost approximately $1,258,866.

Boats drawing five feet can pass through the Des Moines Rapids Canal during extreme low-water.

If it is deemed advisable to give the same available depth and a perfectly safe channel over the Rock Island Rapids, the cuts should be made 400 feet wide, and excavated to a depth of at least 6 feet below low-water of 1864. This would require the removal of 581,835 cubic yards of rock, which would cost approximately $3,491,010.

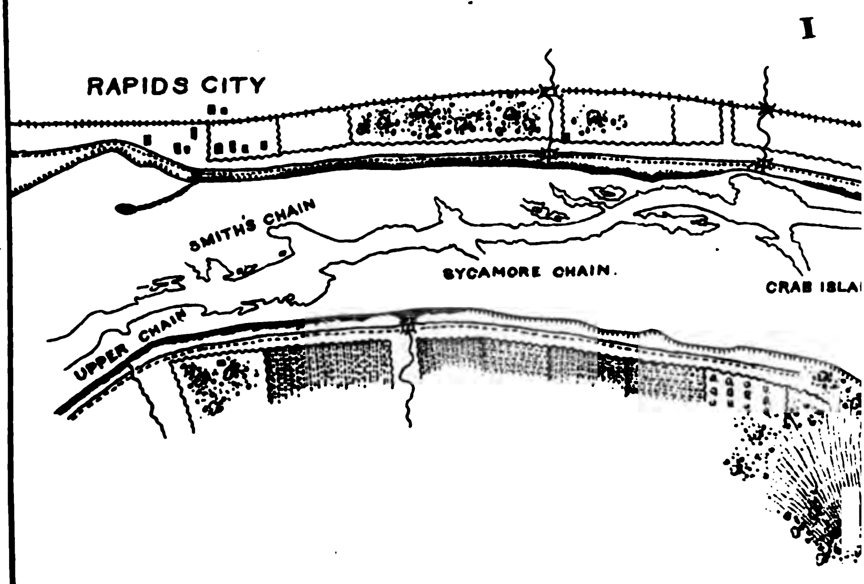
I have estimated the cost of removing rock at $6 per cubic yard, which would be sufficient, provided an appropriation was large enough to justify the building of coffer-dams and a systematic method of working.

The plans present could undoubtedly be so modified during the progress of the work as to require cutting on but one side of the channel, where it is now supposed to require cutting on both sides; such changes, when practicable, will reduce the estimated cost.

The interests of navigation of course require that in time all the proposed work shall be done, but as the obstructions at the Rock Island Rapids are made up of a succession of shoals, the improvement of each may be considered as separate, complete within itself, and benefiting navigation just so much.

The only point in connection with the proposed widening of the channel which has not yet been considered is the effect which the straight-

Note. The curve indicates a channel of 4 ft at low w



ening and improving of present channel would have on the depth of the water and the rapidity of the current.

No effect which can be measured by the most delicate instruments we have has been produced by the work already done, and it can be safely predicted from experiences here and elsewhere that by using the rock excavated for reducing the flow of water at other points the required depth can be maintained.

Should the current be slightly increased, it will not interfere with navigation, provided a sufficient width and depth of channel is given.

During the past season the number of boats, &c., passing through the draw of the Rock Island bridge was as follows:

Steamboats	2,514
Barges	750
Rafts	571

All these boats and rafts passed over the rapids, but it is perhaps unfair to judge of benefits resulting from an improvement of this kind from these figures, for the increased width and depth of channel, by facilitating navigation and reducing cost of water transportation, would develop new interests.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

S 7.

IMPROVEMENT OF HARBOR AT ROCK ISLAND, ILLINOIS.

In compliance with instructions from the office of the Chief of Engineers, under date of September 13, 1879, a report was made by me on November 5. Said report, which is printed in House Ex. Doc. No. 32, Forty-sixth Congress, second session, proposes the removal by dredging of the bar along the levee and of a portion of the large bar which extends down from the foot of the island of Rock Island and covers the steamboat landing. It is proposed during the present season to remove by dredging as much of the bars above mentioned as can be accomplished with the funds available.

ABSTRACT OF APPROPRIATIONS FOR IMPROVING HARBOR AT ROCK ISLAND, ILLINOIS.

By act approved June 14, 1880	$6,000 00

Money statement.

Amount appropriated by act approved June 14, 1880	6,000 00
July 1, 1880, amount available	6,000 00
Amount (estimated) required for completion of existing project	20,759 15
Amount that can be profitably expended in fiscal year ending June 30, 1882.	20,759 15

S 8.

IMPROVEMENT OF HARBOR AT MUSCATINE, IOWA.

A report on an examination of the steamboat landings in front of Muscatine, submitted January 25, 1879, estimated the cost of removing the accumulated deposit of mud at $19,250.

The act of Congress approved March 3, 1879, appropriated $7,500 for commencing the work, which amount was made immediately available by the Secretary of War. Dredging was begun May 12, and between this date and June 30, 1879, $3,831 were expended, leaving a balance of $3,669 available July 1, 1879.

Dredging was continued until July 12, at which date the high-water caused a suspension of work, leaving the harbor in comparatively good condition.

By letter of the Chief of Engineers dated August 12, 1879, authority was given to expend the balance of this appropriation in the removal of an obstruction in the channel just above the city, and a dredge was sent to Muscatine for this purpose. A more detailed examination of the obstruction showed that what had been reported as a mass of bowlders was too solid to be removed by the dredge, and this work had to be temporarily abandoned, the small balance available being used in removing by dredge a gravel point, which caused in part the deposit along the city front.

The removal of the mass of rock above the city, amounting to about 10,000 cubic yards, will be necessary in the future, but does not demand immediate attention, as good channels, which are now found on both sides of it, render it less of an obstruction than is found at many other points. If a low-water examination of this harbor shows that a filling is still taking place, I propose expending as much of the $7,500 appropriated by act approved June 14, 1880, as may be necessary for continuing dredging, using any balance remaining for the commencement of such work as may be necessary for preserving the harbor and channel of the river in this vicinity. The estimate of January 25, 1879, which gave the total cost of dredging required as $19,250, was based upon a survey made at that time, but as changes are constantly taking place at this as well as other localities on the river, the accuracy of this estimate cannot well be determined for some time to come. Assuming this estimate to be correct, there remains to be appropriated, to complete the work, $4,250, and this amount can be profitably expended either in dredging in Muscatine Harbor or in the improvement of the river in the vicinity during the fiscal year ending June 30, 1882.

SUMMARY OF WORK FOR FISCAL YEAR ENDING JUNE 30, 1880.

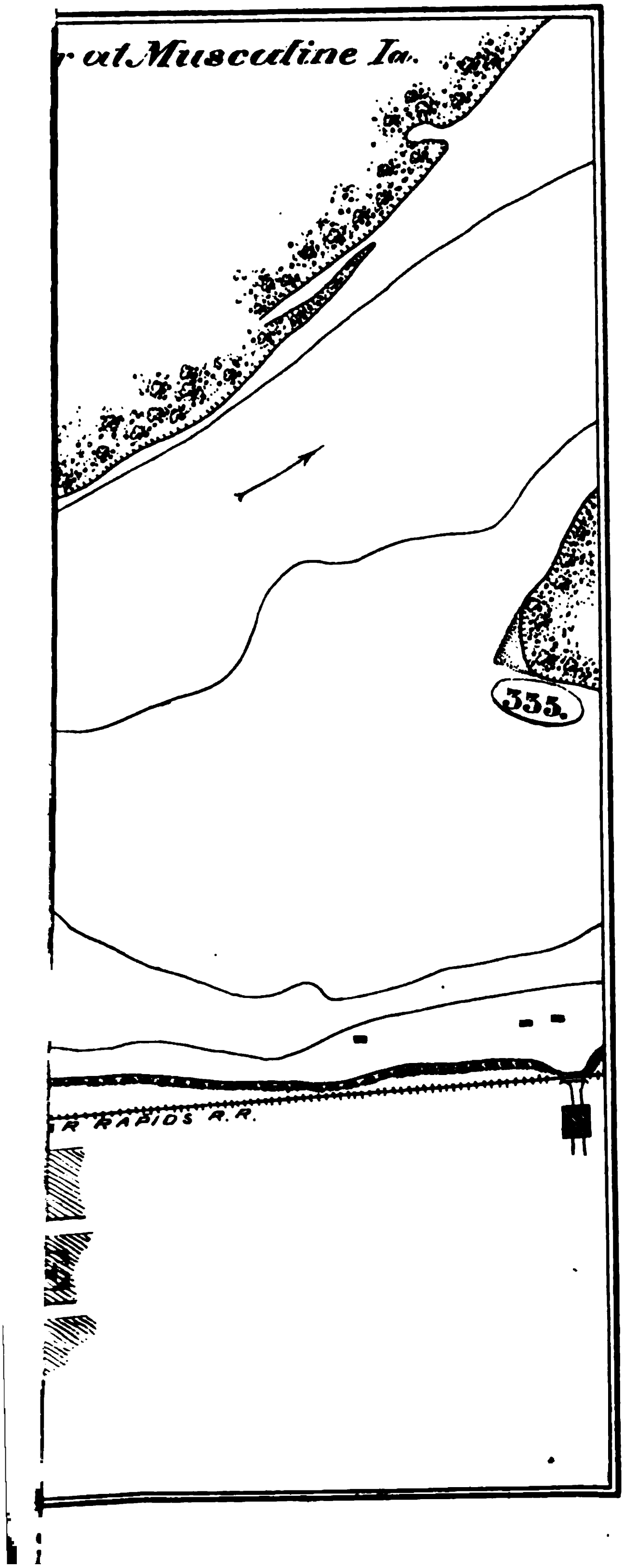
15,107 cubic yards material dredged, at 20 cents	$3,021
Engineering and contingencies	647
Total	3,669

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1879	$7,5[illegible]
By act approved June 14, 1880	7,5[illegible]
Total	15,0[illegible]

Money statement.

July 1, 1879, amount available	$3,669 00	
Amount appropriated by act approved June 14, 1880	7,500 00	
		$11,169
July 1, 1880, amount expended during fiscal year		3,669
July 1, 1880, amount available		7,500
Amount (estimated) required for completion of existing project		4,250
Amount that can be profitably expended in fiscal year ending June 30, 1882.		4,250


r at Musculine Ia.
335.
R RAPIDS R.R.


gton. Ia.
P
BURLINGTON
True Meridian
Note.
indicates a channel of 4.5 ft
ater of 1864.

S. 9.

IMPROVEMENT OF RUSH CHUTE AND HARBOR AT BURLINGTON, IOWA.

The work projected in January, 1879, for the improvement of navigation just above Burlington, was to dredge away a portion of the bar at the head of Rush Chute, protect the banks, and contract the channel at the foot of the chute. None of this work was done during the fiscal year, as the amount of money available was not sufficient to justify a commencement, and it was deemed advisable to wait for and observe certain changes going on at the foot of the chute.

The channel through Rush Chute and just above Burlington is troublesome, and though it did not give as much annoyance last season as many other points, it continues threatening to be very bad. As the proposed work did not immediately follow the presentation of the project, many changes may be found necessary when the work is carried out. What these changes will be cannot be definitely stated until a new low-water examination is made, but, as the changes will certainly not reduce the cost of the work, the original estimate is still adhered to.

With the money available and the amount asked for for fiscal year ending June 30, 1882, it is proposed to remove the bar at head of Rush Chute, protect the banks, and build such spur dams at the foot of the chute as will prevent a shifting of the channel.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$10,000
By act approved June 18, 1878	10,000
By act approved March 3, 1879	5,000
By act approved June 14, 1880	5,000
Total	30,000

Money statement.

July 1, 1879, amount available	$7,670 92	
Amount appropriated by act approved June 14, 1880	5,000 00	
		$12,670 92
July 1, 1880, amount expended during fiscal year		19 21
July 1, 1880, amount available		12,651 71
Amount (estimated) required for completion of existing project		39,656 87
Amount that can be profitably expended in fiscal year ending June 30, 1882		39,656 87

S. 10

IMPROVEMENT OF HARBOR AT FORT MADISON, IOWA.

The original project for this work was presented December 6, 1875. (Report of Chief of Engineers, 1876, part I, page 688.) It consisted in closing Niota Chute for the purpose of throwing more water into the main channel and removing the bars which obstructed the landing at Fort Madison and assisting through navigation of the river. The construction of a closing dam was commenced in 1877, and completed in 1878. The effect of this dam was to somewhat improve the channel in front of the

city wharf. The work proposed at the beginning of the last fiscal year was to build a spur dam from the head of Niota Island to contract the channel and direct the current along the Fort Madison landing. On September 9, 1879, a modified project for the expenditure of the balance on hand was submitted and approved September 13, 1879. This latter project proposed postponing the construction of a dam from head of Niota Island, as such dam might endanger the raft channel, and recommended the raising of Niota Chute Dam,* the protection of Island 391, the connecting of this island with main shore by a causeway, and such dredging as might be necessary for the relief of Fort Madison Harbor and the Ferry Landing on the Illinois shore. This work was all carried out during the past fiscal year.

Fort Madison is badly located for river commerce, and it is difficult to preserve a channel along its front, but the works already constructed are having a beneficial effect, and the narrow but deep channel between the bar and wharf seems to be improving.

Before the improvement of the river in this vicinity can be considered as completed, spur dams must be built out from islands 391 and 392, Niota, and the channel between 392 and 393 must be closed, and for the accomplishment of the above work $8,586.87, the balance of the original estimate, is respectfully asked for.

SUMMARY OF WORK FOR FISCAL YEAR ENDING JUNE 30, 1880.

Niota Chute Dam.	
2,083.7 cubic yards rock, at $1.30	$2 708 81
Naber's Island Dike.	
1,517 cubic yards rock, at $1.30	1,972 10
604.9 cubic yards brush, at 75 cents	453 67
Naber's Island Shore Protection.	
275.7 cubic yards rock, at $1.30	358 41
114 cubic yards brush, at 75 cents	85 50
Dredging at Ferry Landing.	
310 cubic yards sand, at 16 cents	49 60
Superintendence and office expenses	1,250 45
Total	6,878 54

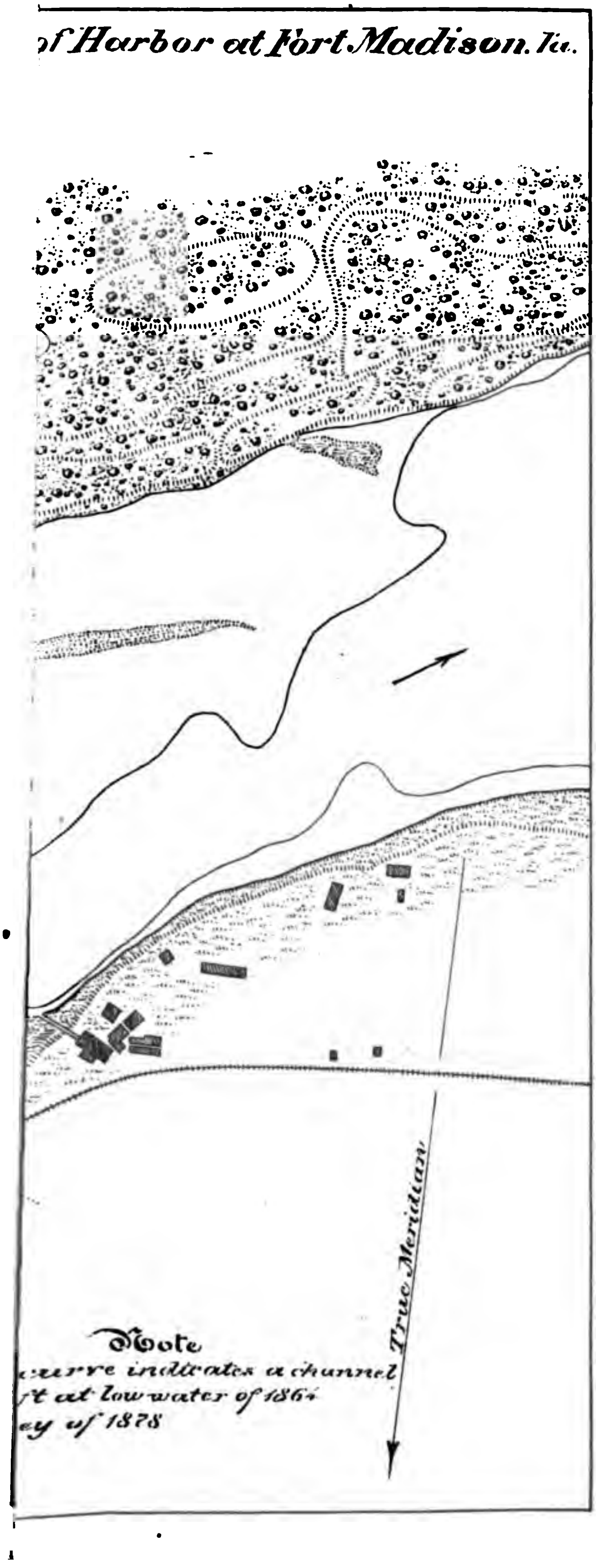
ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$10,000
By act approved June 18, 1878	8,000
By act approved March 3, 1879	3,600
Total	21,600

Money statement.

July 1, 1879, amount available	$6,878 54
July 1, 1880, amount expended during fiscal year	6,878 54
Amount (estimated) required for completion of existing project	8,586 87
Amount that can be profitably expended in fiscal year ending June 30, 1882	8,586 87

* The Niota Chute Dam was built to a height of 2 feet above low-water. An examination made in March 1880 showed that the dam had settled but slightly.


of Harbor at Fort Madison. Ia.
True Meridian
Note
curve indicates a channel
ft at low water of 1864
ey of 1878

Abstract of proposals received and opened August 27, 1879, for building dams and shore protections of brush and stone in the Mississippi River, near Fort Madison, Iowa.

Number.	Names and residences of bidders.	2,000 cubic yards stone.		1,500 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
	H. S. Brown, Hamilton, Ill	$1 30	$2,600 00	$0 90	$1,350 00	$3,950 00
2	Edmond H. Rand, Pontoosac, Ill	1 28	2,560 00	1 23	1,845 00	4,405 00
3	Whitney and Son, Keokuk, Iowa	1 30	2,600 00	75	1,125 00	3,725 00

S 11.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT AND ABOVE THE CITY OF ALEXANDRIA, MISSOURI.

A report on this subject with accompanying project was made by Maj. F. U. Farquhar, Corps of Engineers, January 7, 1879.

The project proposes the construction of three spurs from the right bank and one from the left bank, with a view to contracting the natural water-way. It is proposed to expend during this season the amount now available in commencing work under the project indicated.

ABSTRACT OF APPROPRIATION.

By act approved June 14, 1880 .... $10,000 00

Money statement.

Amount appropriated by act approved June 14, 1880 .... $10,000 00
July 1, 1880, amount available 10,000 00
Amount (estimated) required for completion of existing project 20,945 75
Amount that can be profitably expended in fiscal year ending June 30, 1882. 20,945 75

S 12.

IMPROVEMENT OF NAVIGATION OF THE MISSISSIPPI RIVER AT QUINCY, ILLINOIS.

The act of Congress approved June 18, 1878, provided for a survey or examination of the harbor of Quincy.

A report on the survey with estimates of cost of improvements was submitted by Maj. F. U. Farquhar, Corps of Engineers, under date of January 13, 1879.

An appropriation of $20,000 for improving navigation of Mississippi River at Quincy, Ill., was made by act of Congress approved March 3, 1879, and a project for the expenditure of this money was submitted April 8, 1879. This project was the same as in that portion of the report of January 13, 1879, which referred to improvements in the Mississippi River proper, and consisted in the construction of certain wing and closing dams for the removal of Quincy Bar.

Proposals for this work were asked for by advertisement in several papers, and coming in this way to the knowledge of the citizens of Quincy, the mayor of that city addressed a letter to the Secretary of War requesting that if possible a portion of the appropriation might be expended for the improvement of Quincy Bay. This letter was referred

to me, and I submitted a report dated August 16, 1879, which suggested that if it was deemed expedient and admissible the sum of $10,000 could be expended in dredging in Quincy Bay, as the remaining $10,000 expended on the river would afford as much relief as was being given at other troublesome points. In reply to this report I received the following:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., August 22, 1879.

SIR: The following was telegraphed you to-day, and is hereby confirmed:

"Secretary of War decides that application of $10,000 of appropriation for Mississippi River at Quincy is applicable to dredging the bay, and you are authorized accordingly."

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

GEO. H. ELLIOT,
Major of Engineers.

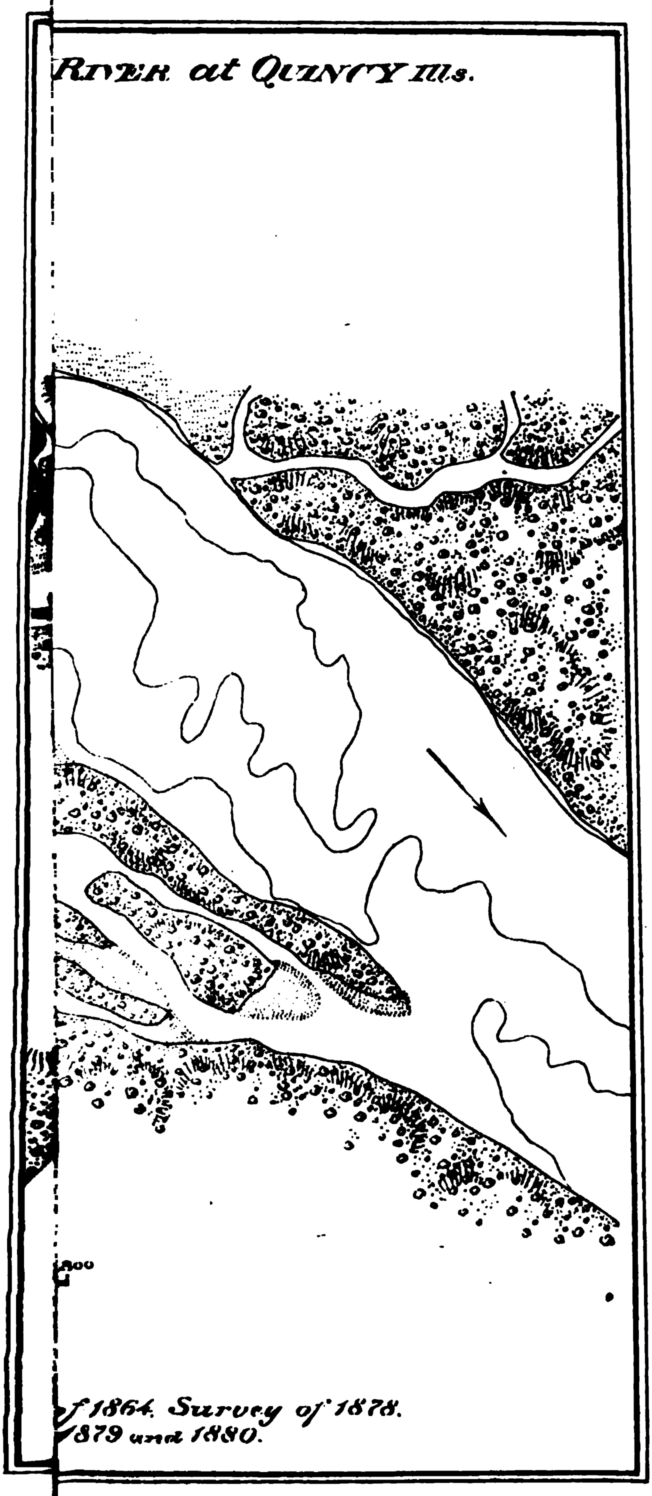
Capt. A. MACKENZIE,
Corps of Engineers.

The work of constructing dams was commenced October 15 under contract with Whitney and son December 11. Two spur dams were built out from the right bank of the river: the first (No. 1, sheet 68) starts about 2,600 feet below the railroad bridge and is some 1,500 feet in length; the second (No. 2, sheet 68) runs out from head of Island 427 and is completed for a length of 300 feet, leaving some 600 feet yet to be built.

The dredging in Quincy Bay was begun under a contract with Whitney & Son, October 13, 1879, continued until December 11, resumed February 17, 1880, and closed May 11, in consequence of appropriation being expended. Channels 4 feet deep at low-water were dredged through the bars both below and above the railroad bridge, the former being 200 feet and the latter 100 feet in width.

A survey in the vicinity of Quincy made in November, 1878, showed a very narrow 4-foot channel across the bar. In the fall of 1879 this crossing became shoaler and more troublesome than for several years previous. A survey made in May, 1880, since the construction of the dams, indicates most beneficial results, and shows a wide and deep channel across the bar. The latter survey was made at the comparatively high stage of 8 feet above low-water and its results are therefore not given in detail. A thorough low-water examination will be made in the fall, when the results can be more accurately determined and reported. I think that but little more work will be required to render the channel in the immediate vicinity of Quincy permanently good, but just below the city the bank is caving for a long distance, and its protection in the near future may become necessary. This work would properly come under this appropriation, although it was not considered in the original report and estimate of January 13, 1879.

The project submitted January 13, 1879, has not yet been approved or ordered to be carried out, but as the appropriations made by Congress are based upon this report, and a decision has been rendered by the Secretary of War that the money appropriated under the title of "Improving navigation of Mississippi River at Quincy, Ill.," can be properly expended in the bay, I assume that I am restricted in my recommendations to this project, and would therefore respectfully recommend that of the $25,000 appropriated by act approved June 14, 1880, the sum of $10,000 be expended in continuing dredging in Quincy Bay, and that the balance be reserved until a thorough low-water examination shows the condition of the bank below the city and what work


RIVER at QUINCY Ills.
800
f 1864. Survey of 1878.
879 and 1880.

may still be required in the river for securing the permanency of the channel. In this case as in many others it is impossible to make other than an approximate project and estimate for improvements to be made in the future or after a year or more has elapsed, inasmuch as the frequent changes which take place in the river channels may necessitate a radical change of plan, and perhaps an increase of cost of the work. If the project for improving Quincy Bay is to be carried out, the sum of $50,000 can be profitably expended on this work during the fiscal year ending June 30, 1882.

Summary of work for fiscal year ending June 30, 1880.

Description.	Rock, at $1.15 per cubic yard.	Brush, at 64 cents per cubic yard.	Mud and sand, at 15.42 cents per cubic yard.	Amount.
Dam No. 1 (sheet 68), 1,500 linear feet	6,877.3	2,442	....	9,471.76
Dam No. 2 (sheet 68), 800 linear feet	933.8	351	....	1,298.51
Dredging in Quincy Bay	....	....	48,900.4	7,531.97
Totals	7,811.1	2,793	48,900.4	18,302.24
Engineering and contingencies				1,445.04
Total amount expended				19,747.28

ABSTRACT OF APPROPRIATIONS.

By act approved March 3, 1879	$20,000
By act approved June 14, 1880	25,000
Total	45,000

Money statement.

July 1, 1879, amount available	$20,000 00	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$45,000 00
July 1, 1880, amount expended during fiscal year	19,622 28	
July 1, 1880, outstanding liabilities	125 00	
		19,747 28
July 1, 1880, amount available		25,252 72
Amount (estimated) required for completion of existing project		179,109 87
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 00

Abstract of proposals received and opened this 27th day of August, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. A., for building dams and shore protections of brush and stone, near Quincy, Ill.

Number.	Names and residences of bidders.	9,000 cubic yards stone.		8,000 cubic yards brush.		Aggregate.
		Per cubic yard.	Amount.	Per cubic yard.	Amount.	
1	H. S. Brown, Hamilton, Ill	$1 30	$11,700	$0 90	$7,200	$18,900
2	Fruin & Co., Saint Louis, Mo	1 60	14,400	80	6,400	20,800
3	Whitney & Son, Keokuk, Iowa	1 15	10,350	64	5,120	15,470
4	W. B. Larkworthy, Quincy, Ill	1 18	10,620	64	5,120	15,740
5	Samuel S. Sample, Keokuk, Iowa	1 09	9,810	82	6,560	16,370
6	Fred. W. Menke and J. H. Bitler, Quincy, Ill.	1 19	10,710	69	5,520	16,230

S 13.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT HANNIBAL, MISSOURI.

Under instructions from the office of the Chief of Engineers, a report was made January 17, 1880, chiefly from data in this office, upon obstructions in the Mississippi River in the vicinity of Hannibal, Mo. This report, which was intended simply as a preliminary one, not having been preceded by an adequate survey, contains a project for the improvement of the river at Hannibal.

Said project proposes: 1. The removal of a large gravel bar lying along the front of the city. 2. The confining of the main channel and principal current to the Missouri shore, to be effected by wing-dams thrown out from the Illinois shore; the closing of Glasscox Island Chute, and protection of a portion of the west side of that island.

It is proposed to defer the expenditure of the amount now available until a thorough low-water survey shall enable us to make more definite plans and estimates.

ABSTRACT OF APPROPRIATIONS.

For improving Mississippi River at Hannibal, Mo., by act approved June 14, 1880	$25,000

Money statement.

Amount appropriated by act approved June 14, 1880	$25,000 00
July 1, 1880, amount available	25,000 00
Amount (estimated) required for completion of existing project	35,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	35,000 00

SPECIAL REPORT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 17, 1880.

GENERAL: As instructed, as per indorsement from office of the Chief of Engineers, dated January 13, 1880, on letter written by the Hon. W. H. Hatch to the honorable the Secretary of War, I have the honor to report as follows:

During November, 1879, by direction of the Chief of Engineers, a dredge was sent to Hannibal and a little work for the temporary relief of the steamboat landing done.

While this work was going on some soundings were taken in the vicinity, and the results are shown on the accompanying tracing.

A large gravel bar, about one-half mile in length, lies along the Missouri shore above the Hannibal landing, and causes a continual deposit in front of the city wharf. This bar should be removed.

To confine the current to the Missouri shore and hold the sand-bars opposite Hannibal, dams should be thrown out from the Illinois shore.

The shoaling caused by these dams will probably destroy the present ferry landing, and therefore one of the dams should be built in the form of a causeway, furnishing a new landing in deep water.

The first work to be done would be the removal of the gravel bar, the construction of causeway or dam No. 2, the construction of a low dam from the Illinois shore to Glasscox Island, and 1,000 feet of shore pro-

tection on the west side of the island, as shown on the accompanying tracing.

Should these dams fail to confine the channel to the Missouri shore, dams Nos. 1 and 3 could be subsequently built.

The material removed from the bar can be used in the construction of dams.

ESTIMATES.

For removal of bar, 60,000 cubic yards of gravel and clay, at 50 cents per cubic yard	$30,000
For dam No. 2, about 1,000 feet long and 12 feet high, containing 10,000 cubic yards, at $1.25 per cubic yard	12,500
For closing dam No. 4, behind Glasscox Island, containing 6,000 cubic yards, at $1.25 per cubic yard	7,500
For 1,000 feet shore protection, at $2.50	2,500
Total	40,000

This work could be done in one season if commenced at an early date.

Should the above work prove insufficient and dams Nos. 1 and 3 be subsequently found necessary, they would cost approximately as follows:

Dam No. 1	$5,000
Dam No. 3	15,000
Total	20,000

The price estimated for dredging is very large and undoubtedly it can be done for much less, but the uncertainty as to hardness and the small number of dredges at present available for such work render it unsafe to reduce the estimate.

Very respectfully, your obedient servant.

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

S 14.

PROTECTING PIERS AT ROCK ISLAND BRIDGE BY MEANS OF SHEER-BOOMS.

The sheer-boom built and placed in position in May, 1878, for the protection and guidance of rafts passing the Rock Island Bridge was of but little service during the low-water season of 1879. At low-water stages, owing to the narrow channels in the upper river and on the rapids, rafts are made of smaller size than at high stages, seldom exceeding 8 or 9 strings in width, which, with the tow-boat attached, readily pass through the outer draw opening, there being no necessity for using either raft-span or sheer-boom. At the close of season of 1879 the booms were towed into winter quarters in Sylvan Water.

On account of the small balance of appropriation remaining, the booms were not put in position at the opening of navigation of 1880.

On March 26, 1880, they were turned over to Maj. D. W. Flagler, Ordnance Department, commanding Rock Island Arsenal.

The absence of the main boom during the high-water of this spring developed its usefulness at such periods, as a number of rafts were dashed to pieces on the bridge piers, which might have been avoided had the boom been in position. In the early part of May the sheer-

boom was, at my request, kindly put in place by Major Flagler, and has since that time been cared for by him. As the appropriation made by act approved June 14, 1880, of $1,000, and calling for an equal sum from the Chicago, Rock Island and Pacific Railroad Company, provides for the care of the sheer-booms, I would respectfully suggest that they be again placed in charge of the Engineer Department.

ABSTRACT OF APPROPRIATIONS.

By act approved August 14, 1876	$15,000
By act approved June 14, 1880	1,000
Total	16,000

Money statement.

July 1, 1879, amount available	$723 74	
Amount appropriated by act approved June 14, 1880	1,000 00	
		$1,723 74
July 1, 1880, amount expended during fiscal year		407 75
July 1, 1880, amount available		1,315 99
Amount that can be profitably expended in fiscal year ending June 30, 1882.		1,000 00

S 15.

IMPROVEMENT OF GALENA RIVER AND HARBOR, ILLINOIS.

A report on a survey of Galena River, submitted by Maj. F. U. Farquhar, Corps of Engineers, December 29, 1873 (Report Chief of Engineers 1874, Part I, page 289), suggests a plan of improvement, the cost of which is estimated at $400,000. Dredging was commenced September 16, 1878, in accordance with the proposed plan, and has been continued during the past fiscal year under two contracts: 1. An extension granted H. S. Brown & Co., who completed their work August 7, 1879; and, 2. A contract with Whitney & Son, who commenced work April 11, 1880.

For the purpose of furnishing relief to the commerce of this river as soon as possible, a narrow cut affording 4½ feet at low-water is first being made over the entire length. At present date this cut, which commenced at the mouth, is within 7,900 feet of Galena, and it can be completed with the money now available. As new appropriations permit a continuation of the work, this cut will be widened.

An excellent survey of the river from Galena to its junction with the Mississippi was made by Inspector J. C. McElherne, in August, 1879.

Results accomplished to June 30, 1880: A channel 5½ miles long, 35 to 100 feet wide, and affording a least depth of 4 feet at low-water, has been cut from the mouth of the river to a point 1½ miles from the city of Galena. Total excavation, 174,696 cubic yards mud and sand.

SUMMARY FOR FISCAL YEAR ENDING JUNE 30, 1880.

72,902.40 cubic yards material excavated	$13,067 17
Superintendence, office expenses, &c.	1,270 95
Total expended	14,338 12

The $12,000 appropriated for fiscal year ending June 30, 1881, will be expended in continuing dredging.

COMMERCIAL STATISTICS.

Shipments for one month of 1879:

Hog product	pounds..	2,278,000
Lead	do....	460,000
Grain	bushels..	370,000
Hides	pounds..	45,000
Zinc ore	do....	74,400
Lumber	feet..	518,145
General merchandise	pounds..	220,000

ABSTRACT OF APPROPRIATIONS.

By act approved June 18, 1878	$30,000
By act approved March 3, 1879	12,000
By act approved June 14, 1880	12,000
	54,000

Money statement.

July 1, 1879, amount available	$17,981 07	
Amount appropriated by act approved June 14, 1880	12,000 00	
		$29,981 07
July 1, 1880, amount expended during fiscal year	13,351 23	
July 1, 1880, outstanding liabilities	986 89	
		14,338 12
July 1, 1880, amount available		15,642 95
Amount (estimated) required for completion of existing project		346,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		50,000 09

Abstract of proposals received and opened August 27, 1879, by Capt. A. Mackenzie, Corps of Engineers, U. S. Army, for dredging in the Galena River.

Number.	Names and residences of bidders.	For dredging and depositing material at a distance less than 6 miles.	For dredging and depositing material at a distance less than 5 miles.	For dredging and depositing material at a distance less than 4 miles.	For dredging and depositing material at a distance less than 3 miles.	For dredging and depositing material at a distance less than 2 miles.	For dredging and depositing material at a distance less than 1 mile.	Aggregate.
		Cubic yd.	*Cubic yd.*	*Cubic yd.*	*Cubic yd.*	*Cubic yd.*	*Cubic yd.*	*Cubic yd.*
1	H. S. Brown, Hamilton, Ill.	$0 30	$0 27	$0 26	$0 24	$0 22	$0 20	$1 49
2	Whitney & Son, Keokuk, Iowa.	27	25	22	20	17	15	1 26

S 16.

IMPROVEMENT OF CUIVRE RIVER.

The act of Congress approved March 3, 1879, provided for a survey or examination and estimates of cost of improvement of Cuivre River, Missouri.

This survey was assigned to me, and $600 allotted for the work. The survey was made in the fall of 1879, and a report submitted January 10, 1880, which is printed in Senate Ex. Doc. No. 36, Forty-sixth Congress, second session.

The project contained in the above report proposed:

1. The excavation, by dredging, of a channel 80 feet wide through the four shoals in the Cuivre River.

2. The excavation, by dredging, of a channel 100 feet wide through the three sand-bars in the upper part of Cuivre Slough.

3. The construction of a dam with its crest 6 feet above low-water across the lower part of Cuivre Slough, for the purpose of backing up, and thereby increasing the depth in the upper part of the slough.

4. The removal of snags, wrecks, and overhanging timber.

The above project was made with reference to a 2 feet minimum depth on the bars at extreme low-water.

It is proposed to apply the amount now available, or as much of it as may be necessary, to the removal of snags, wrecks, and overhanging timber during the present season.

ABSTRACT OF APPROPRIATION.

By act approved June 14, 1880 .... $2,000

Money statement.

Amount appropriated by act approved June 14, 1880	$2,000 00
July 1, 1880, amount available	2,000 00
Amount (estimated) required for completion of existing project	28,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	28,000 00

EXAMINATION AND SURVEY OF CUIVRE RIVER, MISSOURI.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 29, 1879.

GENERAL: I have the honor to submit herewith map of Cuivre River, Missouri, together with a report upon the survey and examination of this stream, made in accordance with your instructions dated July 25, 1879.

A preliminary examination of the river showed that a point known as "Chain of Rocks," 14½ miles from the mouth of Cuivre River, might be properly considered as the head of navigation.

From this point to the mouth a good depth of water was found in the stream, excepting at four points, where gravel bars formed obstructions to navigation during ordinary stages.

Cuts through these gravel bars 80 feet wide, and averaging 2 feet deep, and the removal of snags will render the river navigable for boats drawing 4 feet at ordinary stages of low-water.

From the character of the stream, its banks and bed, and the absence of all current except in times of freshets, it can be assumed that the improvement of the river proper would be reasonably permanent.

The river empties into Cuivre Slough, which connects it with the main channel of the Mississippi River.

This slough being filled with moving sand, and fresh supplies of sand above being ready to move in during high water, its improvement presents difficulties, and permanency cannot be insured.

The plan of improvement proposed is by a dam at the lower end of the slough, to raise the water at the mouth of the river about 1 foot, and by doing away with current through slough at ordinary stages of the river, to enable a dredge to cut a channel through the thin bars in upper branch of slough, which channel will probably be permanent until the next high-water following the improvement.

To insure a permanent channel a little dredging must be provided for

yearly. The approximate cost of the improvement of the river and slough so as to give 4 feet of water at a 2-foot stage is $30,000.

A very rich country is tributary to the river, and undoubtedly much good would result from its improvement; but, as no reliable statistics could be obtained, it is impossible to give more than an approximate comparison of results, with the cost.

The detailed report of Assistant Engineer C. W. Durham is appended.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., December 24, 1879.

CAPTAIN: I have the honor to present the following report and accompanying map of a survey of the Cuivre River, Missouri, made, under your direction, by Assistant J. H. Morrison, November, 1879. The report includes a plan and estimate for the improvement of the river from Chain of Rocks to its mouth, a distance of 14½ miles, and also for the improvement of the slough into which it debouches, in order to make a navigable outlet to the main channel of the Mississippi River. I have made use of much information contained in the excellent report of Mr. A. H. Blaisdell, assistant engineer, on a survey of this river made by him under direction of Lieut. Col. W. F. Reynolds, Corps of Engineers, August, 1871, which report may be found in the Report of the Chief of Engineers for 1872, page 391.

DESCRIPTION.

The Cuivre River is formed by the junction of the North and West Forks, the former rising in Ralls and the latter in Audrain County. Both forks are augmented by numerous small streams, which scarcely deserve the name of creeks in the dry season, but in times of continued rain, flowing as they do from the high bluffs, they become turbulent in their character, and bring considerable sediment into the stream to which they are tributary. The general trend of the river is easterly, through Lincoln and Saint Charles Counties, pursuing, however, a very tortuous and winding course, with many sharp bends and elbows. The total drainage area is about 1,600 square miles.

MOSCOW MILLS TO CHAIN OF ROCKS.

The upper portion of the river from Moscow Mills to Chain of Rocks is full of shoals and narrow passages or island chutes, with insufficient water at low stages to float a skiff. Great numbers of snags and drift piles also add to the difficulties of navigation, in view of which facts it was considered inadvisable to make plans and estimates for the improvement of this part of the river, as the business is not commensurate with the enormous cost which would result if any effectual improvement were attempted.

CHAIN OF ROCKS TO MOUTH OF RIVER.

The lower portion of the river from Chain of Rocks to its mouth is included within the scope of this survey, and for the improvement of this portion plans and estimates are submitted. It resembles in character the bayous of the Lower Mississippi and other Southern rivers, there being no perceptible current except in times of freshets, its rise and fall corresponding with the fluctuations of water-surface in the larger river. It varies in width from 300 feet at mouth to 150 feet at Chain of Rocks.

A little below Chain of Rocks there is an excellent landing with ample depth of water. Passing down the river, we find a good channel of from 4 to 9 feet at extreme low-water for about 1,000 feet, when Seed Tick Island Bar is reached.

Seed Tick Island Bar.—A reach of shallow water about 2,000 feet in length. A portion of this bar is dry at low-water, and the average depth is only a few inches. It forms the worst obstruction in that part of the river under consideration. From here to Flood's Bar, about half mile below Monroe, a distance of some four and a half miles, we find from 4½ to 18 feet of water.

Flood's Bar.—About 850 feet in length, with an average depth at low-water of about

1 foot. From here to Shelton Bar, a distance of nearly two miles, we have from 4 to 12 feet in the channel.

Shelton Bar.—A very shallow reach about 850 feet in length, situated in a bend of the river, and of an average depth of about 6 inches at low-water, a great part of it being dry at that stage.

Morrison's Bar.—About 300 feet below Shelton Bar; 550 feet in length, and of an average depth at low-water of about 6 inches.

From Morrison's Bar to the mouth of the river, a distance of about eight miles, there is a good channel of from 4½ to 8 feet.

The bars above mentioned are composed of sand and gravel, material probably easily taken up by dredge.

CUIVRE SLOUGH.

The Cuivre River empties into the Mississippi River through Cuivre Slough, included between Cuivre Island (No. 504) and the Missouri shore. In the slough going *south* from the mouth of the river the water is very shoal, and hardly susceptible of effectual improvement without great expense. Going *north* we find much better depth, there being, however, three shallow sand-bars, which may be removed by dredge at inconsiderable cost. These are—

Cuivre Slough Bar No. 1. Near head of Cuivre Island, 700 feet long, and of an average depth at low-water of about 1 foot.

Cuivre Slough Bar No. 2. About 900 feet long; average depth, 1 foot.

Cuivre Slough Bar No. 3. Near mouth of Cuivre River; 850 feet long; average depth, about 9 inches.

With the exception of these bars, there is a good passage to the channel of the Mississippi River.

SNAGS.

There are a large number of snags in the channel between Chain of Rocks and the mouth of the river, and several in the upper part of Cuivre Slough. There is also considerable overhanging timber and a sunken barge a short distance below Monroe.

BRIDGES.

There is a skew draw-bridge of the Saint Louis and Keokuk Railroad near Monroe, with openings of 60 feet. There being no current in the river, the passage of the bridge can be safely made except in a high wind.

STATISTICS.

The country tributary to the river is thickly settled and in a high state of cultivation, the products being wheat, corn, hay, tobacco, and fruit. Large numbers of cattle and hogs are annually sent to market. There is a large business done in timber and cord-wood, cut on the bottom-lands adjacent to the river.

Coal and iron abound in Lincoln County. The principal shipping point is Chain of Rocks, a village of about one hundred inhabitants. At Monroe considerable traffic is carried on. It was impossible to obtain accurate statistics of the amount of shipments, no systematic record being kept by shippers.

PROJECT.

For the improvement of Cuivre River and Cuivre Slough, a minimum depth on the shoals of 2 feet at extreme low-water is assumed as the object desired. This will afford from 4 to 5 feet during the greater part of the navigable season of the Upper Mississippi, or for about six months in the year, and is amply sufficient, being in fact nearly as much water as there is in the larger stream at a corresponding stage. Any increase of this minimum depth would greatly augment the cost of the proposed improvement, as may be seen by reference to the 2-foot curves drawn on the map.

I would, then, respectfully propose—

1st. The excavation by dredging of a channel 80 feet wide, and of a minimum depth of 2 feet at low-water, through the 4 shoals in the Cuivre River. As there is no perceptible current and but very little sediment in this part of the river, and the material of the bottom and shores being generally of a comparatively stable nature, it is believed that no addditional work would be necessary for many years. A comparison of the map of this survey with the report on the survey of 1871 shows but a trifling enlargement of the bars during the intervening period.

2d. The excavation by dredging of a channel 100 feet in width and of a minimum depth of 2 feet at low-water through the three sand-bars, in the upper part of Cuivre

Slough. An additional width of 20 feet is given, as the material is less stable, and the cut is more liable to be filled with shifting sand. It is believed, however, that the work will be reasonably permanent, and that a few days' dredging each year will suffice to keep the passage open.

3d. The construction of a dam across the lower part of Cuivre Slough, 2,600 feet from the foot of Cuivre Island. The dam will be about 450 feet long, constructed of brush and rock, with its crest 6 feet above low-water mark. With the necessary shore protections it will contain about 3,000 cubic yards of material, and, estimating for this quantity placed in position at $1.50 per cubic yard, will cost about $4,500. This dam will be of much benefit during the low stages by backing up the water in the slough and river, and by checking the current will prevent in great measure the filling up of the upper portion of the slough by sand from the Mississippi.

4th. The removal of snags, wrecks, and overhanging timber. The estimate for this work is $1,000.

The location of all the proposed work is shown on the map.

Dredging estimate.

Number.	Name.	Distance from channel of Mississippi.	Length of proposed cut.	Average depth of excavation.	Cubic yards (at 50 cents per yard).	Cost.
		Miles.	*Feet.*	*Feet.*		
1	Cuivre Slough Bar No. 1	0.5	700	1.5	3,888	$1,944
2	Cuivre Slough Bar No. 2	1.5	900	1.5	5,000	2,500
3	Cuivre Slough Bar No. 3	1.8	850	2.0	6,296	3,148
4	Morrison's Bar	10.0	550	1.5	2,444	1,222
5	Shelton Bar	10.2	850	2.5	6,296	3,148
6	Flood's Bar	12.0	850	1.0	2,518	1,259
7	Seed Tick Island Bar	16.5	2,000	3.0	17,778	8,889
	Total				44,220	22,110

SUMMARY.

Dredging and removal of 44,220 cubic yards sand and gravel, at 50 cents	$22,110
Dam across Cuivre Slough	4,500
Removal of snags, wrecks, &c	1,000
Engineering contingencies, &c	2,390
Total estimate	30,000

These figures provide for the improvement of the upper part of Cuivre Slough and of Cuivre River to Chain of Rocks, a distance of 16½ miles.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Capt. A. MACKENZIE,
Corps of Engineers, U. S. A.

APPENDIX T.

IMPROVEMENT OF THE DES MOINES RAPIDS OF THE MISSISSIPPI RIVER AND OPERATING THE CANAL.

REPORT OF CAPTAIN AMOS STICKNEY, CORPS OF ENGINEERS, BVT. MAJOR U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 23, 1880.

GENERAL: I have the honor to transmit herewith my annual report of the work on the improvement of the Des Moines Rapids of the Mississippi River and for operating and maintaining the canal under my charge during the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Captain of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

IMPROVEMENT OF DES MOINES RAPIDS, MISSISSIPPI RIVER, AND OPERATING THE CANAL.

The work has consisted principally of removal of rock from river channel, between Nashville and Montrose, by means of a stream-drilling scow and dredge; grading and inclosing lock grounds; laying riprap-face wall; operating the canal for navigation, including dredging and repairs.

All work on this improvement during the past year has been done by hiring the labor and purchasing material in open market.

CHANNEL EXCAVATION.

The scow which was fitted up with Ingersoll steam-drills, for use in drilling and blasting rock in river channel between Montrose and Nashville, and which was described in the annual report for the fiscal year ending June 30, 1879, has been in operation during the greater portion of the past year.

Owing to the delay caused by the non-arrival of a shipment of dynamite the drilling scow did not commence work until the latter part of August, 1879. The work has continued except during a portion of the winter, when the river was frozen over, or ice running so thick as to prevent the handling of the scow. Some very useful work was accomplished during a portion of the winter on patches of rock, whose proximity to the channel used by steamers made work, except during a cessation of navigation, very slow and costly if not impossible.

Work with this drilling scow is conducted as follows: Iron tripods, resting on the bottom of the river, are located opposite each range to be worked over, parallel to the channel-line and 10 feet distant from it; their positions being determined by an instrument from established stations on shore.

The drilling scow is moved in positions parallel to the tripods, its length being up and down stream, the distance from the tripods being determined by measurement with a chain, and the location up and down stream being maintained by ranges on the shore. When in position for work the spuds are set, and a line of holes $3\frac{1}{4}$ inches diameter and 4 feet apart (16 in all if so many are required on one line) are drilled to a depth of 18 inches below grade; a small flat-boat is then brought alongside the scow, and from this flat-boat the work of filling the holes with charges of dynamite is carried on.

A long copper tube $2\frac{5}{8}$ inches diameter, with a slot one inch wide extending its entire length, is first inserted in the down-stream hole, and a stream of water from a steam pump is carried down into the hole through a pipe attached to a hose; this is for the purpose of washing out the sand and gravel which in some places is carried along the bed of the river in large quantities. After the hole is clean, the dynamite, made up into cartridges $2\frac{1}{2}$ inches diameter and containing $\frac{1}{2}$ pound each, is passed down the copper tube, the wires which connect with the cap contained in the upper cartridge extending out through the slot; sand is then poured down the tube to weight the cartridge and so prevent its being lifted out by the current.

The number of cartridges placed in each hole is regulated by the depth of hole. Under 20 inches, one; between 20 and 30 inches, two; from 30 to 36 inches, three. After an entire line of holes has been filled in this manner, and the wires connected between the cartridges, the end wires are connected with heavier insulated wires run on reels on the drilling scow to facilitate paying out. The spuds are then raised, and the scow is swung out of danger, usually from 30 to 50 feet from the blast, by means of a head-line and side-lines. A magneto-electric blasting machine is connected with the reels, and a current sent through the line which heats the platinum wire contained in the exploders, and thus discharges the dynamite. After the explosion of the blast the scow is moved into a new position, 4 feet nearer the tripods than on the former occasion, and the process of drilling and blasting repeated as before. By this method there is the advantage of working back from a face cutting after the outside line of holes has been blasted.

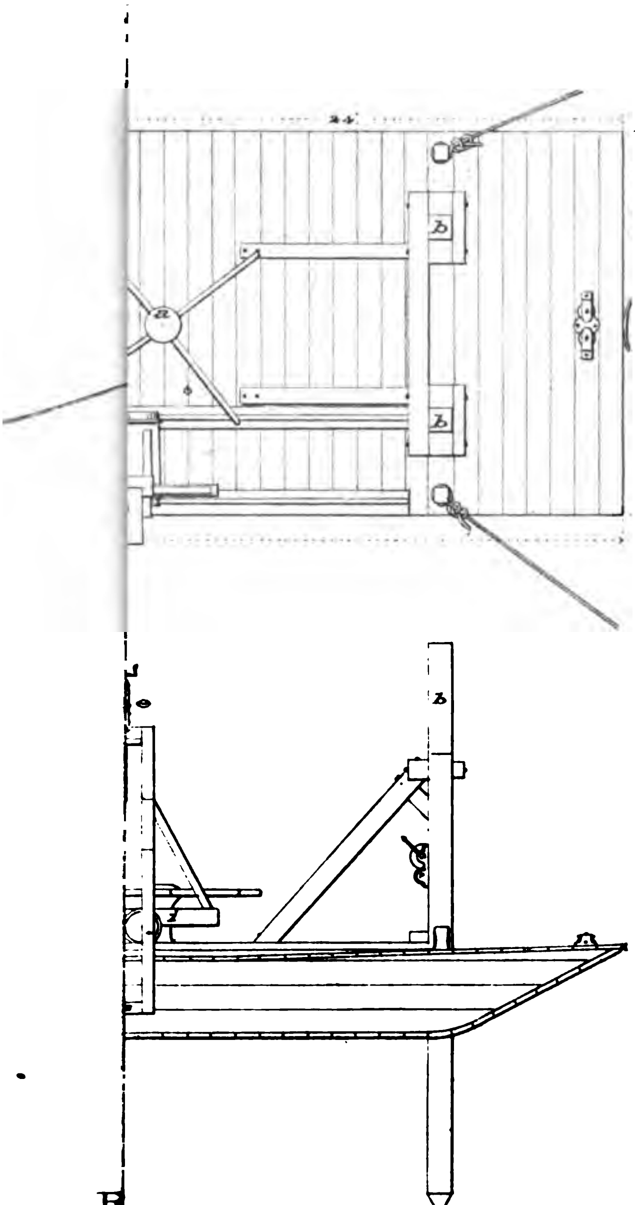
The work was commenced August 27, on a long reef or series of reefs on the east side of channel, nearly opposite Miller's Run. Owing to the peculiar character of the rock, which we learned only by experience, and after some trouble and slight delays in the work, the depth of the holes drilled was found insufficient (the original depth used in drilling being 6 inches below grade). Since increasing the depth to 18 inches below grade the work has been prosecuted with great success.

The drilling scow was moved up to the head of Montrose coffer-dam February 24, and excavation of channel at that point commenced.

This work is in continuation of the channel excavated by coffer-dam in 1875 and 1876.

The high-water of June compelled the suspension of work with the drilling scow, and the scow, flat-boats, &c., were moved down and placed in the canal for safety June 24.

The character of the rock operated on varies greatly in different localities and at different depths in the same locality. It consists of compact



R

a.a..

b.b.b.b. RILLING SCOW

c. excavating the channel

d. for the

e.e. t of the Des Moines Rapids.

f.

h.h. Scale. 8 ft to 1 in.

i.i.

4 8 12 16

limestone with cherty bands and shales, sometimes alternating in layers and sometimes consisting of only one of these.

The shale contains many geode formations, with Millerite zinc-blende and calcite crystals, the whole series of rock forming a conglomerate which is calculated to resist a rapid movement of the steam-drills.

Where the rock was firm compact limestone the best execution was done, both in drilling and in the effect of the blast; the rock seeming to lift up from the seam nearest the bottom of the hole. Where the rock consisted largely of shale, with some chert, the blast was expended in creating a crater, and it was to insure keeping the highest point of the sides of these craters below grade that the depth of 18 inches below grade for the hole was adopted.

The steam-dredge belonging to this work was employed removing from the channel rock which had been chiseled in previous years and rock which had been blasted by the steam-drilling scow during the past year. This rock was placed in piles along the Iowa side of channel, 50 feet distant from the channel line, and these piles serve to indicate the position of channel.

During the prosecution of the work of dredging the dredge was several times run into by passing steamers and slightly injured, but no serious damage was done. Some repairs were necessitated, which will be alluded to elsewhere in this report.

A table herewith appended shows the amount of work performed in excavating channel by steam dredge and drilling scow, together with statistics of interest regarding the drilling scow specially.

The drilling scow having been at work most of the time since April 11 (the date when dredge ceased work in channel excavation and moved into canal), there remains a quantity of blasted rock yet to be dredged.

Summary of work done by drilling scow.

Number of holes drilled.	Total depth in feet drilled.	Pounds No. 2 dynamite used.	Number of fuses used.	Length in feet of 1¼-inch octagonal steel used.	Area of surface drilled over in square feet.	Area made available as channel in square feet.	Number of cubic yards blasted.
3,685	8,436	4,762	3,763	85	56,370	100,288	*2,368

* The number of yards blasted as given above refers to rock above grade; a considerably greater quantity was actually blasted in order to make sure of grade.

SUMMARY OF WORK DONE BY DREDGE.

Removed chiseled rock	cubic yards..	913.8
Removed blasted rock up to April 11, 1880	do......	1,317
Total quantity dredged		2,230.8
Cost per cubic yard of rock blasted		$3 08
Cost per cubic yard of rock dredged and placed in piles		2 09
Total cost per cubic yard		5 17

A considerably greater quantity than above given was actually dredged, owing to the blasting being below grade at points, and to the accumulation of sediment. The cost per yard is the whole cost of blasting and dredging divided by the number of yards of material above grade.

REPAIRS TO DREDGE, DRILLING SCOW, ETC.

During the winter and at other times the dredge has been repaired and improved. The old auxiliary engine used to operate the spuds and capstans having become worn out was replaced by a new double-cylinder engine, the cranks set at an angle of 90 degrees with each other; the valve gear consisting of forward and backing eccentrics on each side connected with a common reverse lever, so that the engine can be run in either direction without trouble from standing on the centers. This engine has given perfect satisfaction ever since it has been in use. General repairs have been made to the machinery, including spud-gear and spuds. The dipper used on rock work was thoroughly repaired during the winter, and new steel teeth riveted on. The deck of dredge has been repaired by the insertion of some new plank and calking.

On June 27, the overturning of a kettle containing boiling tar, which was being used in making repairs, caused a fire in the after cabin of the dredge, and but for prompt action on the part of the crew, and the assistance rendered by crew of H. S. Brown's dredge, must have resulted in the total destruction of the hull and great injury to the machinery. The fire was, however, confined to the after cabin, and finally extinguished. The sides, roof, and all partitions were so injured as to make it necessary to replace them. A part of the cabin furniture was entirely destroyed. None of the framing timbers were seriously injured; and, as the fire was not permitted to reach the machinery, the work of dredging has gone on without interruption.

Carpenters are now employed restoring the cabin, according to the original plan.

Scows, &c.—The dump-scows and flat-boats have been repaired when necessary. For this purpose temporary ways have been established on ground owned by the government just above the guard lock, this being the nearest available point to the scene of operations of both dredge and drilling scow.

Two capstans have been placed on the dump-scows to facilitate handling them in the river current.

The drilling scow has been hauled out on the ways and thoroughly calked, new planking being inserted where required. Two capstans for handling the scow have been purchased during the past year, and also a small Cameron steam-pump for use in supplying water, under high pressure, for cleaning the drill-holes of sand and gravel.

The boiler used to furnish steam to the Ingersoll steam drills is an old one, having been in use on this work since August 20, 1873. It was originally used in pumping out coffer-dams, and has become worn out in some parts During the month of May leaks started from cracks in flue-sheet and sides of fire-box, and although temporary repairs were made at the time, yet it was found necessary to have thorough repairs made, including a new flue-sheet and resetting the flues and a new chimney.

While it was at the boiler shops, a manhole was cut in the top, and supplied with cover clamps, &c., to facilitate the cleaning of the flues and removal of scale.

GRADING AND COMPLETING LOCK GROUNDS, ETC.

At the lower lock it was found necessary to protect the slope between the wagon road and the sluice with sod, as the angle of slope was too great to admit of grass seed taking root, the wash from rains being considerable. Accordingly this portion of the lock grounds was covered

with sod. Fourteen thousand eight hundred square feet in all were laid carefully and rolled. The season being very favorable it has taken root and is growing well. Several trees which have been injured by frost have been removed and new trees substituted.

At the middle lock a bridge has been constructed over the sluice exactly similar in size and design to the one at the lower lock, a row of shade trees has been planted along the road leading through the lock grounds, and grass-seed planted on both sides of the road.

At the guard lock a force of carpenters, laborers, and teams have been employed constructing a fence similar in design to the middle and lower locks, to inclose the lock grounds; in grading the lock grounds, and constructing permanent roads where required; in rebuilding the old temporary shops, and making such changes in them as were necessary to adapt them to present purposes for storage and repair work These buildings are generally similar to those mentioned in a previous annual report as having been constructed at the lower and middle locks. Painters are now engaged in painting all exposed wood-work thoroughly in two coats.

LAYING RIPRAP FACE WALL.

A force of laborers was set at work August 1 building up the riprap face wall on the inside of the river embankment of canal, and on the approaches to guard lock, and a small quantity of wall as a foundation for a wall to be heareafter constructed about one mile below Sandusky, on the shore side of canal; the stone used in this work being delivered on the bank where required by Messrs. Wells, Timberman & Co. This work was continued throughout portions of the months of August, September, October, November, February, and March. Four thousand and twenty-three cubic yards of new wall were laid in the canal.

The guide pier above the guard lock which marks the position of the channel was found to be in very bad shape, several steamers having collided with it and torn the stone out of place. A gang of laborers was set to work rebuilding it. When the stone was partly removed it was discovered that the greater portion of it had so deteriorated from the action of the frost and current that it would be necessary to replace it with new stone. One hundred and fifty cubic yards of new wall were laid on this pier, the bottom courses for a distance of 4 feet above low-water being laid in hydraulic cement. The stone originally used in the construction of this pier had been taken from the excavation in Nashville coffer-dam No. 1, and had seemed sufficiently good for the purpose. Small gangs of laborers have been from time to time engaged in making slight repairs on the wall on inside of canal embankment, at places where stone had been displaced by steamers striking it.

The bank on shore side about one mile below Sandusky being too low to admit of carrying the wall above the water surface and there being danger of the railroad embankment washing, a force of men and teams were employed during the winter months when the canal was drained, in hauling material with which to raise this bank. The work extended during portions of the months of January, February, and March, during which time the bank was raised to a point 2 feet above high-water in canal, and the front protected with rough stone ready for wall laying; 2,657 cubic yards of earth were hauled and placed in the bank at this time. Since the opening of the canal for the season of 1880 a quantity of refuse stone and gravel was removed from the guard-lock grounds

during the progress of the grading, conveyed by flat-boats to this new bank and placed on top as an additional protection.

OPERATING AND MAINTAINING CANAL.

The canal was in continuous operation without serious accident or delay during the season of 1879, until December 9.

On December 1 the use of the hydraulic machinery for operating the lock gates was discontinued, the joints of all water connections with the cylinders broken, and the wells which contain the cylinders packed with straw to prevent a recurrence of the accident of the previous winter.

The locks were, however, operated by hand for the accommodation of stray steamers until December 9, when, due notice having been given to steamboatmen, the canal was closed and both levels drained.

During the winter at the three locks the machinery was overhauled and slight general repairs made by the lock hands.

At the lower lock the boiler was supplied with a wooden jacket covered with Russia sheet iron and secured by brass bands. Since using the boiler protected in this manner a considerable economy in fuel has been effected.

At the middle lock the old distributing valve which had given trouble from leakage was replaced by a new valve of similar size and design to the one in use at the guard lock, and this new valve has given entire satisfaction ever since it has been in use.

The canal was opened for navigation in the spring March 8, 1880, and continued in operation until June 24, when, on account of very high water in the Mississippi, it was closed to the public.

On June 22 the river had risen to a level with the water in the canal, and both sets of gates at the lower lock were thrown open, permitting steamers to pass directly through this lock. The water continuing to rise the lock-gates were entirely submerged on the 24th, and although the small steamers employed in towing dredged material out of the canal continued to pass through, yet it was deemed unsafe for large steamers, or those having tows, to pass through, on account of the danger of injury to the exposed portions of the machinery.

The canal was accordingly closed on the 24th as above stated, due notice having been given to steamboatmen.

The water continued to rise until it became stationary on June 28, and on June 29 began to fall, but slowly.

The highest point reached was 17.5 feet above low-water mark of 1864, being .35 feet higher than the high-water of 1876.

The lock-walls were submerged to a depth of 1.75 feet.

Observation thus far has shown no injury done the canal as the result of this flood, but it was deemed wise to put a small force of laborers at work protecting the embankment at places where the wall had not been carried to its full height, and where the bank threatened to cave.

The winter rains conveyed a great quantity of sand, gravel, &c., from the creeks which drain into the canal, and besides this there had been an accumulation of sand, mud, &c., ever since the completion of the canal, and this had been only partially removed by dredging at various times.

At a point in the canal opposite Price's Creek, the sand had formed a bar extending entirely across the canal, and so high as to practically blockade passage. At this point a force of laborers and teams were employed during the minter, when the canal was drained, cutting a channel 100 feet wide down to grade, in order to admit of the passage of

steamers when the canal should be opened, until such time as the dredge could complete the work.

The dredge belonging to this work was employed during portions of the months of July and August, 1879, and of April, May, and June, 1880, in removing bars which had formed at various points in the canal, notably at points opposite Price's and Lamallee's creeks. The dredged material was towed out into the river and dumped; the steamer Cricket, owned and operated by Messrs. Wells, Timberman & Co., being employed to tow the loaded dump scows.

The dredge-steamer, and four dump scows, constituting the outfit, owned and operated by H. S. Brown & Co., were hired to assist in the work of removing sand and mud from canal. This outfit commenced work May 10, and continued working up to June 30, the dredged material being dumped in the river.

SUMMARY OF WORK DONE IN REMOVING SAND AND MUD FROM CANAL FOR FISCAL YEAR ENDING JUNE 30, 1880.

	Cubic yards.
Removed by teams during the winter	1,288.0
Removed by United States dredge	26,495.5
Removed by H. S. Brown & Co.'s dredge	11,552.5
Total	39,336.0

In my last annual report I called attention to the necessity of building a part of the lock-walls higher at the middle and lower locks, and placing a structure to facilitate entrance of guard lock, and made estimates therefor. The amount appropriated for this improvement for the coming season is so small that it will allow of nothing being done to the lock-walls, and but a commencement of the guard-lock structure. The other work remaining to be done on the canal consists principally of building riprap face-wall, and the funds provided will permit but little to be done.

The cost of this wall will be increased by every year's delay, owing to the wash of the embankment.

The appropriation for operating the canal this year is $30,000, a reduction of $10,000 from the amount estimated.

The canal can be kept in operation with the amount provided, but a large amount of dredging must be postponed, and portions of the canal in the vicinity of the creeks which empty into it will be reduced in depth and navigable width. After a thorough dredging at these points it is probable that a comparatively small amount of dredging each year will keep the canal in good condition, and the annual appropriation of $30,000 will be sufficient for operating and maintaining, except in case of extraordinary repairs.

The canal is at present in good navigable condition, with normal depth somewhat reduced at points opposite creek mouths. The locks and their machinery are in good order. The channel of the river from the head of the canal to Montrose will, with a little dredging, be in such condition that boats carefully handled will have no difficulty in making the passage, except in times of high wind.

During the fiscal year ending June 30, 1881, it is proposed to continue the excavation of the river channel between the head of the canal and Montrose; commence the structure of cribs and timber fenders at guard-lock entrance; build a small amount of riprap face-wall, and continue operating and maintaining the canal for navigation. It is proposed to apply the amount asked for the fiscal year ending June 30, 1882, to the

completion of the aforementioned work and the building up of parts of the middle and lower lock-walls to prevent the over-riding of the guards of boats.

A complete survey of both sides of the canal embankment, the two sides together being nearly 15 miles in length, made since last annual report, develops the fact that a greater amount of stone will be needed for riprap face than was estimated for, the increase being accounted for principally by the settling and spreading of the banks, which, when filled up, have longer slopes than the original. Portions of the bank where the wall was finished to the top are shown by the survey to have settled from 1 to 2 feet, and in portions where the bank has remained unprotected by wall it has spread so that the slopes are flatter than when built. About 4,000 yards additional wall will be required, and the bank must be refilled.

The cost of dredging in river channel this year was considerably greater than the estimate on account of the accumulation of sand and gravel about the broken rock which was chiseled four years before and could not be dredged at that time for want of funds.

The fencing, grading, &c., of lock grounds and various finishing work about the canal has also proved more expensive than was anticipated.

These items render it necessary to add to the previous estimates of cost of completing the work.

Attention is called to the fact that this increase in the estimates is caused in great part by the fact that the work has dragged along under insufficient appropriations which compelled parts of the work to remain for a long time in an unfinished condition.

The work remaining on June 30, 1880, to be done to complete this improvement, is as follows:

Blasting and dredging 4,120 yards rock, at $5	$20,600 00
Dredging 1,051 yards rock, at $1.25	1,314 00
Purchasing and laying riprap face-wall, 23,584 yards, at $3.25	76,648 00
Laying riprap face-wall, 1,500 yards, at 75 cents	1,125 00
Building cribs and fenders at guard-lock entrance	6,000 00
Building up walls at lower and middle locks	16,000 00
Refilling canal bank	3,000 00
Finishing lock grounds	1,000 00
Engineering, superintendence, office, and other expenses	6,000 00
Total	131,687 00
The amount of funds available for this work	35,106 50
Total	96,580 50

I desire to express my appreciation of the services of Assistant Engineers R. R. Jones and O. S. Willey, and Messrs. C. P. Comegys and B. Railey in my office.

The following statement shows the business of the canal during the fiscal year:

Statement of steamboats, barges, rafts, &c., passed through the Des Moines Rapids Canal from July 1, 1879, to June 30, 1880, fiscal year ending June 30, 1880.

Month.	Steamboats.	Barges and flats.	Cargo.			Rafts.					Lockages at one dock.
			Passengers.	General merchandise.	Grain.	Number.	Lumber.	Logs.	Shingles.	Lath.	
	No.	No.	No.	Tons.	Bushels.		Feet.	Feet.	No.	No.	No.
July	133	57	5,172	6,567	324,912	4	2,018,496	1,934,960	500,000	....	285
August	103	60	2,225	8,515	152,513	11	14,188,574	2,525,000	3,687,000	2,756,000	325
September	129	101	1,542	10,985	252,784	26	30,712,212	4,255,000	7,785,750	6,076,675	330
October	127	90	948	8,373	165,299	31	46,384,853	2,470,000	8,803,850	12,945,315	369
November	108	74	470	8,821	253,906	19	27,778,343	1,976,000	8,484,550	6,085,650	262
December	5	6	......	971	15,000	....	....	....	....	....	6
March	89	30	86	2,373	74,753	....	....	....	....	....	71
April	91	91	403	8,308	204,479	....	750,000	....	1,300,000	....	134
May	142	90	1,261	23,713	428,420	....	....	....	....	....	306
June	90	52	1,124	10,363	325,403	....	....	....	....	....	409
Total	967	651	13,231	78,989	2,197,469	91	121,832,478	13,160,960	30,561,150	27,863,640	2,497

NOTE.—The canal was closed 89 days, from December 9 to March 8, on account of cessation of river navigation, and 7 days, from June 24 to June 30, on account of extreme high-water. The boats and barges at work in the canal are not included in this statement except in the number of lockages.

This work is located in the collection district of New Orleans. Saint Louis, Mo., is the nearest port of entry.

The following is a statement of the collections at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1880:

Duties on imports		$1,143,738 88
Marine Hospital tax		13,680 93
Fines and penalties		331 97
Inspections—steam vessels		6,097 70
Licenses—officers of steam vessels		8,275 00
Storage		1,465 69
Official fees		2,419 40
Total		1,176,003 57
Steam vessels enrolled, 162	tons..	59,699.13
Barges enrolled.......157	tons..	82,275.81
Total...........319	tons..	141,974 94
The estimated complete cost of this work as now being carried on is		$4,437,515 00
Cost of operating and maintenance of canal from August 22, 1877, to June 30, 1881		157,565 00
Estimated cost of operating and maintenance of canal for fiscal year ending June 30, 1882		40,000 00
Total		4,635,080 00
Total amount appropriated for all purposes up to June 30, 1880		4,498,500 00
Amount required yet to be appropriated for finishing improvement and operating canal		136,580 00

Money statement.

July 1, 1879, amount available	$85,875 06	
Amount appropriated by act approved June 14, 1880	50,000 00	
		$135,875 06
July 1, 1880, amount expended during fiscal year	68,435 12	
July 1, 1880, outstanding liabilities	2,333 44	
		70,768 56
July 1, 1880, amount available		65,106 50
Amount (estimated) required for completion of existing project		96,580 00
Amount (estimated) for operating and maintaining canal for fiscal year ending June 30, 1882		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		136,580 00

APPENDIX U.

PRESERVATION OF THE FALLS OF SAINT ANTHONY AND IMPROVEMENT OF THE MISSISSIPPI ABOVE THE FALLS—IMPROVEMENT OF CHIPPEWA AND SAINT CROIX RIVERS, WISCONSIN, AND OF MINNESOTA RIVER AND RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA—SURVEYS FOR RESERVOIRS AT THE SOURCES OF THE MISSISSIPPI—CONSTRUCTION OF DAM AT LAKE WINNIBIGOSHISH.

REPORT OF CAPTAIN CHARLES J. ALLEN, CORPS OF ENGINEERS, BVT. MAJOR, U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, Minn., July 15, 1880.

GENERAL: I have the honor to submit herewith the annual reports upon the works and surveys under my charge for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

U 1.

PRESERVATION OF FALLS OF SAINT ANTHONY, MINNESOTA.

The work, during the fiscal year, has mainly consisted in the construction of a sluice-way at the westerly end of the apron for the running of loose logs over the falls, and protection and repair of the toe of the apron which had been seriously damaged by running logs over it. The details of this work are given in the report of Capt. C. J. Allen, Corps of Engineers, under date of December 6, 1879, which, together with sub-report, is printed in Senate Ex. Doc. No. 37, Forty-sixth Congress, second session; reference is herewith respectfully made to it, as part of this report. The sluice was ready for use by the early part of October last, although the gate was not mounted until February.

During the month of March last, the toe of the apron was further strengthened by throwing in large blocks of limestone of 1,000 to 2,000 pounds weight each, at the easterly angle, in anticipation of floods, as there had been a heavy precipitation over the water-shed of the river during the past winter. Two hundred and eighty-five cubic yards of rock were placed, at $2 per cubic yard.

The floods of May and June reached a higher point than known since 1867, and the immense mass of water had only the narrow width of 500

feet over the apron for egress to the river below, the mills and other private works having, previous to the adoption of the present project for the preservation of the falls, already encroached upon the water-way so as to leave only the width above mentioned. The late floods appear to have done considerable damage to the apron, in places, but the extent of such damage can only be ascertained after the subsidence of the water.

The present plan here noted as original project contemplated the stoppage of erosion of the limestone bed of the falls, by means of closing the enormous channels worn under the limestone ledge and through the soft underlying incipient sandrock, by filling of gravel, clay, &c., the construction of a concrete dike under the limestone ledge reaching from extreme banks, remodeling and reconstructing the apron to prevent recession of the crest of the falls, rolling dams to maintain sufficient depth of water upon the bed of the falls to prevent ice from adhering to the ledge in severe winters, and the protection of the toe of the apron by means of bowlder riprapping. The undermining of the toe of the apron by the action of floods and running of loose logs, whether by accident or design, makes it evident that nothing but heavy buttress-work of tight cribs filled with stone will effectually protect it. Should the apron be carried away, the destruction of the falls and the magnificent water-power of this locality would follow unless the work were immediately renewed. Prevention of any such disaster costs but a small fraction of that of renewal. If the United States retain charge of this work, at least $50,000 should be on hand with which to meet damage from floods, or other sources.

During the month of June past, owing to present and prospective damage to the works from running of loose logs, the necessary facts were placed in possession of the United States district attorney in order to enable him to obtain from the United States court an injunction against running loose logs over or through the works, excepting through the sluice built in accordance with the act of Congress approved March 3, 1879. It is not known at the date of this writing that any steps have been taken towards securing the injunction.

Congress, by act approved June 14, 1880, appropriated—

For repairs and contingencies of public works at Saint Anthony's Falls, Minnesota, to meet necessary repairs, present and prospective, ten thousand dollars.

It is proposed to expend this sum, as well as the small balance of funds on hand, in the preservation and further strengthening of the timber work for the protection of the falls, so far as the amount will go.

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenues collected during the fiscal year ending June 30, 1880, amounted to $4,964.51.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING THE FALLS OF SAINT ANTHONY.

By act approved June 11, 1870 *	$50,000 00
By act approved March 3, 1871 *	50,000 00
By act approved June 10, 1872 *	50,000 00
By act approved March 3, 1873 *	50,000 00
By act approved June 23, 1874	125,000 00
By act approved March 3, 1875	100,000 00
By act approved August 14, 1876	120,000 00

* These sums were used before the adoption of the present plan.

By act approved March 3, 1879*	$10,000 00
By act approved June 14, 1880†	10,000 00
Total	565,000 00
Original estimate for carrying out present project	529,726 31
Remaining to be appropriated	174,726 31

Money statement.

July 1, 1879, amount available	$13,391 87	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$23,391 87
July 1, 1880, amount expended during fiscal year	12,812 41	
July 1, 1880, outstanding liabilities	135 11	
		12,947 52
July 1, 1880, amount available		10,444 35
Amount (estimated) required for completion of existing project		174,726 31
Amount that can be profitably expended in fiscal year ending June 30, 1882, to meet repairs necessary, present and prospective		50,000 00

COMMERCIAL STATISTICS.

LOGS.

There were 4,500,000 feet of logs, valued at $22,500, run over the Falls of Saint Anthony, destined for the boom below, during the season of 1879.

It is stated that there will be 4,000,000 feet of logs, valued at $28,000, run over during the season of 1880.

MANUFACTURES AT MINNEAPOLIS (FALLS OF SAINT ANTHONY).

[Taken from "Statistics of Minnesota for 1879."]

The growth of manufacturing industries in the city in 1879 far exceeds that of any former year. This is especially true of the manufacture of flour. At the commencement of the year the entire capacity of the mills running was not over 5,000 barrels daily; at the close of 1879 it was 10,000 barrels, and when the two mills now building and approaching completion are put into operation it will be 15,000 barrels. Another mill will be erected during the year which will increase the capacity to about 18,000 barrels per day. Of course it cannot be expected that these mills will all be run during the year to their full capacity, but it is fair to estimate the annual product at 4,500,000 to 5,000,000 barrels.

STATEMENT OF SHIPMENTS OF FLOUR FROM MINNEAPOLIS FOR THE YEARS NAMED.

	Barrels.
1879	1,551,789
1878	940,786
1877	935,544
1876	1,000,676
1875	843,769
1874	727,157
1873	585,009
1870	193,814
1865	96,000
1860	30,000

Minneapolis millers formerly found a market for their flour mainly in America, and had introduced it into nearly every market East and South, and its reputation had become national.

* For sluice-way through public works, &c.
† For repairs and contingencies, &c.

Not satisfied, however, with this, a little more than two years since active measures were inaugurated to build up a foreign demand. The result was that in 1878, 109,183 barrels were shipped direct from the mills to foreign ports, and in 1879 the exports were 450,000 barrels. In 1878 the shipments were exclusively to English ports; in 1879 they have been to all ports in the United Kingdom; several French, German, Spanish, and Italian ports; to Alexandria, Egypt, and South American ports, at all of which Minneapolis flour is received with great favor.

LUMBER.

The mills of the city manufactured during the season of 1879, 145,000,000 feet of lumber, 50,000,000 shingles, and 21,616,000 lath; an increase of 15,000,000 over 1878.

MISCELLANEOUS MANUFACTURES.

The growth of the manufacturing industries of Minneapolis is by no means confined to the flour interests. All other lines are keeping pace with the growth of the country. The product of the various establishments which are engaged in manufacturing goods for the trade foots up for the year $6,950,725.

COMPARATIVE STATEMENT FOR FOUR YEARS.

1879	$6,950,725
1878	5,696,625
1877	4,802,300
1876	3,776,133

SPECIAL REPORT.

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, December 6, 1879.

GENERAL: I have the honor to report the following as the operations at the Falls of Saint Anthony for the past season:

Congress, by act approved March 3, 1879, appropriated the sum of $10,000 for the construction of a log sluice at the falls, in the following terms:

> For sluice-way through public works at Saint Anthony's Falls, Minnesota. $10,000: *Provided*, That no part of said sum shall be expended for right of way, and that said improvement can be made without expense in the United States, further than the actual construction of said sluice-way.

This appropriation was, shortly afterwards, made available, but the commencement of the work was delayed from two causes, viz: 1st, the existence of high-water; 2d, the delay consumed in acquiring releases to the United States from the owners of water-power at the falls for any water that might be drawn off from their canals or races in order to float logs through the sluice. These releases were all obtained by about the middle of June, 1879; the plan for the work was approved of by the Chief of Engineers; and the construction was begun as soon as the water lowered sufficiently. The sluice is located at the westerly end of the apron protection; is 451 feet in length, over all, having four different slopes or planes on the entire length, the total fall which generates the velocity being about 40 feet on 312 feet horizontal. The width is 6 feet in the clear throughout. The construction is of crib-work, from 4 feet to 8 feet in width, strongly put together, and the sluice lined on the sides with 3-inch plank, securely bolted to heavy timbers, all projecting points carefully chamfered with the adze, and the bottom protected at exposed points with layers of strap-iron. The entrance to the sluice proper is through a sort of tunnel through a large guard-crib at the westerly end of the apron, placed to protect the mills

at that point from the impact of ice and floating bodies. It is 11 feet 6 inches in height and 6 feet in width, to be closed by a gate, worked by screws. The original intention was to make the entrance 8 feet 6 inches high and to use ordinary stop-plank in lieu of a gate, but the experience of the past season proving the disastrous effect upon the apron of running loose logs over it, at any stage of water, it was concluded to make the entrance sufficiently high in the clear to afford no excuse whatever for running logs over the falls, excepting through the sluice-way provided by law.

The sluice was ready for use by the latter part of September, and logs were run through it successfully; but the construction of the gate was deferred, as the entire force of laborers was necessarily diverted to the repairs upon the apron, to be referred to further on. The work is a thorough success; logs run through the sluice with great rapidity and no interruption to their passage can possibly occur, unless the channel at the foot of the chute is clogged with mill refuse. The gate will be mounted during the present month.

Early in the summer it became apparent that the toe of the apron was suffering considerable damage from the action of the floods upon the soft sandstone bed of the stream. As the stage of water receded, the logs, which were passing over the falls in large numbers, contributed to aggravate the damage. The managers and owners of the logs were requested to discontinue running them over the apron, and were assured that the sluice would soon be ready for use.

No action being taken by them to stop the logs, the matter was brought, through the Engineer Department, before the Department of Justice, and the United States district attorney at Saint Paul having received the necessary instructions, an injunction was obtained from the United States court for this district, restraining the running of logs over the apron. There will be, after this season, no possible excuse for not running the logs through the sluice provided; and the Minneapolis Mill Company will, as their agent gave assurance last June, provide for the passage of logs through their works above the sluice. A boom should be placed, by the log-owners, in the pool between the upper and lower rolling dams, so as to sheer the logs into the sluice built by the United States Government, and refuse the apron.

As seen as the wate subsided sufficiently, a careful examination and survey was made of the toe of the apron and the channel below; two large gaps were found in the timber work, viz, one about the middle of the lower edge or toe, and one in the angle near Farnham & Lovejoy's mill-pond. The break in the middle was the first observable; the other not becoming apparent until later. The bowlder protection placed below the apron in the winter of 1877 and 1878 had, nearly all, been swept away by the flow of water, and much of the stone filling in the crib foundation of the apron had also moved out, allowing the timber to float and lift up the apron planking for a width of about 200 feet, and a depth, measured up stream, of 20 to 30 feet.

It became apparent that prompt measures should be taken to restore the work, as nearly as possible, to as good condition as it was in when completed in 1877. The preservation of the log-sluice also depended largely upon that of the apron itself. The balance of funds available was totally insufficient for repairs. The Minneapolis Mill Company, recognizing that their interest hinged upon the preservation of the works, donated sufficient timber for temporary repair, and this was worked into place by the government force of laborers. The repairs consisted mainly in the substitution of water-tight cribs for the open-

work cribs where the greatest damage had occurred. If the United States Government is to retain charge of the preservation of the falls, at least $25,000 should be available at once to perfect the work. A footing of loose bowlders might afford protection to the toe for some time to come, and cost much less than crib-work, but such protection is precarious owing to the action of the floods and ice in carrying the bowlders away, in addition to the small resistance offered by the soft sandstone of the river bed, the stone seeming to yield to the action of the water, and the bowlders spreading out over it for a considerable distance. The toe of the apron should be protected by tight crib-work below it and extending across the width of the stream, the top of the planking to the crib-work to be about 8 feet below the surface of low-water, the crib-work to act both as a protection to the bed of the stream and to prevent action of the eddies, boils, &c., upon the foundation of the apron. The greater part of the proposed work can be done this winter and early in the spring, before the highest water sets in, if funds are available at an early date.

The injury to the work in the angle at the easterly end of the apron seems to have been aggravated somewhat by the injudicious placing of flush-boards by the owners of the mill-privilege at that end of the apron, a fact that was not discovered until the flush-boards had been in position for some time.

The rest of the work at the falls is in good condition.

The report of Mr. J. P. Frizell, assistant engineer, herewith inclosed, gives the details of the work accomplished.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JOSEPH P. FRIZELL, ASSISTANT ENGINEER.

ENGINEER OFFICE, U. S. ARMY,
Saint Paul, December 1, 1879.

SIR: I have the honor to present the following report of operations at the Falls of Saint Anthony during the past season, this work having been under my immediate supervision.

The act of Congress approved March 3, 1879, appropriated $10,000 for the construction of a sluice-way through the public works at the Falls of Saint Anthony. The amount was made avilable shortly after the passage of the act, but the high-water did not abate sufficiently to admit of the commencement of the work before the first of August.

Before the commencement of the work, the precaution was taken to procure releases from the several owners of water-power at the falls, exonerating the government from any claim for damages by reason of the diversion of water from the mills and canals of the said owners by the operation of the sluice.

The sluice was located on the westerly side of the apron, commencing at a point about 130 feet above the crest of the lower rolling dam, which was built for the purpose of keeping the limestone flooded with water. It discharges into a channel separated from the main river by a bank of loose stone and gravel, being the channel which receives the water from several of the saw-mills. It was constructed of 12″ x 12″ square timber fastened with drift bolts. One side is formed by 3-inch longitudinal planking, fastened to upright timbers, which are bolted to the Minneapolis Mill Company's high dam and to the wall, partly natural and partly artificial, which forms the westerly side of the apron. The other wall of the sluice is of close crib-work, 4 feet to 8 feet wide, filled with stone. The side next the sluice is lined with 3-inch plank. The rolling dam was cut through, and the bottom of this part of the sluice, comprising a distance of about 63 feet, consists of 6-inch plank bolted to the lime rock. The sluice is 6 feet wide inside. For a distance of 79 feet from the foot of the roll-dam it takes

the same slope as the apron, viz, about 1 perpendicular to 5 base, and in this part the floor is of 6-inch plank, bolted to the floor of the apron. Thence for a distance of 143 feet it takes a slope of about 7½ base to 1 perpendicular. Thence level to the end, a distance of 58 feet. In these two last portions its bottom consists of 12-inch timber. At the foot of the sluice the water is about 5 feet higher than the river, passing over a little cascade before reaching the latter. The bottom is protected at the parts most exposed to abrasion from logs, viz, a distance of about 180 feet, by 6 straps of wrought iron, ½ inch thick, and 3 inches wide, confined by 12-inch bolts with countersunk heads. The guard-crib at the westerly end of the rolling dam was taken away to make room for the sluice and rebuilt over the latter, leaving a clear opening 11 feet 6 inches high. The sluice, for a distance of some 69 feet, where the water from the saw-mills falls into it, is covered with 6-inch planking. The lower end is protected by a riprap of heavy stone.

The work was executed entirely by day labor, under the direction of Mr. A. H. Weeks as overseer. The materials have been purchased in open market, except the stone, which has been procured mainly in the immediate vicinity at the cost of quarrying and moving. About 219,000 feet of lumber and 30,000 pounds of iron were used in addition to that contained in the old guard-crib. The greater part of the lumber was purchased for $7.97 per M; $10 and $11 was paid for small quantities of better grade. The iron cost 3 and 3½ cents per pound.

The sluice is now entirely completed, except the gate, which will be a plain, old-fashioned, up-and-down gate, worked by screws. The mechanism is now in course of construction.

The only accident which occurred during the construction of the sluice was the drowning of George Boyd, a laborer. He was crossing the river in a boat just above the lower rolling dam while a violent storm was impending. The wind commenced to blow with great fury just after he started, and he was swept over the apron.

Many logs have been passed through the sluice, which fulfills its purpose perfectly.

THE APRON.

It became apparent during the continuance of high-water that serious damage had been done to the apron. It gave evidence of being disturbed at the toe for a width of some 200 feet, and two gaps of considerable width appeared. The Saint Paul Boom Company claimed the right, pending the construction of the sluice, of running logs over the apron, and actually did send over a large number, amounting to some millions of feet of lumber. The damage to the apron, though not wholly due to this cause, was obviously much extended and aggravated by it. Accordingly, through the Engineer Department at Washington, the matter was brought to the notice of the Department of Justice, and the district attorney at Saint Paul was instructed to act in the matter.

About the middle of September an injunction was issued by the United States district court at this place restraining the owners of logs from turning them into the river to find their way over the apron. No further trouble has been had from this cause, though it is proper to add that no logs could have been run in the low stage of water which has prevailed since the date of the injunction.

The small amount of money available for the Falls of Saint Anthony did not appear to warrant the commencement of the extended repairs required by the apron. The execution of this work, however, was so important to the owners of water-power, especially to the Minneapolis Mill Company, that this company offered to donate the lumber required for the repairs. This put the government in a position to undertake the work, and about the first of October it was commenced. The greatest damage occurred near the easterly angle, where the water comes down two slopes, which form a valley. The bottom at this part had been protected in the winter of 1877–'78 by a riprap of heavy bowlders, reaching nearly to the surface of the water. On commencing operations this season a depth of 28 feet was found. The damage to the apron appears to have been largely due to the reflex action of the water in undermining the crib-work and taking out the stone, the cribs having been sunk with open bottoms, as is customary in harbor work. The cribs, deprived of their ballast, floated and raised the apron at the toe. This action must have been much aggravated by logs, which, on reaching the bottom of the apron, do not always proceed on their way, but take part in the rolling and whirling action of the water, and remain pounding against the crib-work. In proof of this, logs were found under the floor of the apron, where the crib-work was broken through.

In executing the repairs, the floor, what remained of it, was removed as far as the disturbance had extended, viz, for a width of some 200 feet, and 20 to 30 feet up and down stream. All unsound timber-work was removed, and even sound work as far as necessary, to get depth for sufficient ballasting of the cribs. Dynamite was freely used for detaching the timber. The work below water consisted of cribs of 12″ × 12″ square timber laid close with lock joints. They measured 16 feet in width, and

20 feet up and down stream. They were generally built highest at the down-stream end, the water being deepest there. The lower timbers were fastened together with 36-inch screw-bolts; the rest with drift bolts and oak treenails. All the cribs had tight bottoms, *i. e.*, tight enough to hold stone. In the deep cribs the bottom was laid on the lower cross-ties. In the shallowest the planking was below the ties, confined thereto by screw bolts, an arrangement giving more room for ballast. On the cribs were laid and bolted the cross-ties which support the flooring of the apron. This consists of two thicknesses; the first of 8-inch timber, the second of 4-inch plank. The flooring is fastened wholly with oak pins or treenails: the 8-inch timber by 16-inch round pins 2 inches diameter; the 4-inch plank by square pins 1¼ inch diameter, 10 inches long. This work was also done by day labor. It was finished in the latter part of November; 157,000 feet new lumber, about 7,500 pounds iron, and some 10,000 treenails were used.

The chief danger to this structure is in the undermining action of the water at the toe. If the government is to be charged hereafter with the maintenance of this work, some defense against this action must be adopted. The readiness with which the heaviest bowlders are washed out inspires doubts as to the efficiency of any loose stone protection, especially in the line of the junction of the two slopes, where the action of the water is most violent. A protection of brush and stone has been suggested, but probably could not be made strong enough to resist the action of ice. Crib-work appears best suited to the purpose, but would be attended here with peculiar difficulties, as the problem would be to sink cribs with 6, 8, or 10 feet of water over them and leave them filled with stone with a strong deck or platform over the top, since it is obvious that cribs open at the top would be deprived of their ballast by the action of the water and floated away. The only method of constructing and placing such cribs that I can conceive of would be to make them water-tight. After loading them to the water's edge, add a curb or bulkhead around the top, giving them sufficient buoyancy to float full of stone. Then fill and cover them, protecting the top with iron plates, straps, or old railroad bars if necessary. Float them into position and sink them by cutting through the curb. The latter, being of light material, could be detached or left to be destroyed by the water; $20,000 would be judiciously expended in a protection of this kind. In other respects, the works for the preservation of the falls are in excellent condition. The concrete dike, so far as can be observed, fulfills its purpose well.

Very respectfully, your obedient servant,

JOS. P. FRIZELL,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

U 2.

IMPROVEMENT OF MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

The balance of funds on hand at the close of the fiscal year ending June 30, 1879, was too small to admit of resuming work, as the steam-crane scow would have required extensive repairs.

Operations have consisted, mainly, in inspection of work done between Saint Cloud and the Falls of Saint Anthony and the care of property. The months of May and June, 1880, were remarkable for heavy rainfall and corresponding floods, doing more or less damage along the whole length of the river.

An examination of the stream above Saint Paul was made in June by a small party, in order to obtain data as to damage, &c.

The original estimate for the work between Saint Cloud and the Falls was $144,667.50, the work to consist in removal of obstructions, closing of secondary channels, island chutes, and protection of banks.

This estimate is contained in report upon part of the Third Subdivision, Mississippi Transportation Route, under date of February 8, 1875, in order to furnish estimates to meet the recommendation of the Senate select committee on transportation routes to the seaboard. The same report contains estimates for making the improvement as far up the

river as Grand Rapids, the total cost for a channel 5 feet deep estimated at $2,156,578,75; and for a channel 3 feet deep, $2,030,220.50.

One steamer, only, plied prior to 1879 between Minneapolis and Saint Cloud. Large quantities of logs are, however, run down the river and received into booms. The work of improvement upon this stretch of river has been confined to the points between Saint Cloud and Minneapolis, where the worst obstructions existed, and, no doubt, some benefit to log-driving accrued. The loggers, however, frequently tear out the dams in order to obtain short routes through the chutes for the passage of logs. It has been impossible thus far to detect the depredators.

If work between Minneapolis and Saint Cloud is to continue, $40,000 can be profitably expended during the fiscal year ending June 30, 1882, as a dredge-boat will be required for thorough removal of bowlders and gravel. Probable cost of the dredge $20,000.

Congress, by act approved June 14, last, appropriated for—

Improving Mississippi River, above the Falls of Saint Anthony: continuing improvement, fifteen thousand dollars.

It is proposed to expend this sum mainly in the improvement of the stream between Grand Rapids and Brainerd, the latter at the crossing of the Mississippi by the Northern Pacific Railroad; the work to be done by day labor. The stretch of river above Brainerd is possessed of better natural depth and has more commerce, logging excepted, than any stretch of equal length below it.

The original estimate for improvement between Couradis Shoals, 35 miles below Brainerd, and Grand Rapids, is, for a 5-foot channel, $54,127.50, the improvement to consist in removal of snags, bowlders, sand, clay and gravel bars, leaning trees, and the construction of wing-dams. The sum of $25,000 can be profitably expended upon this reach of the river during the fiscal year ending June 30, 1882.

Total amount that can be profitably expended upon the Mississippi River above the Falls of Saint Anthony for the fiscal year ending June 30, 1882, viz:

From Couradis Shoals to Goose Rapids, and above	$25,000 00
Between Minneapolis and Saint Cloud, if improvement upon this stretch of river is to be kept up by the United States	40,000 00

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minn., at which place the revenue collected for the fiscal year ending June 30, 1880, amounted to $4,964.51.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

By act approved June 23, 1874*	$25,000 00
By act approved August 14, 1876	20,000 00
By act approved June 14, 1880	15,000 00
	60,000 00
Original estimate for the work between the Falls of Saint Anthony and Saint Cloud, Minnesota	144,667 50
Remaining to be appropriated	124,667 50
Original estimate for the work between Grand Rapids and Couradis Shoals	54,127 50
Appropriation act approved June 14, 1880	15,000 00
Remaining to be appropriated	39,127 50

* Made and expended before the adoption of the present project.

Money statement.

July 1, 1879, amount available	$2,646 76	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$17,646 76
July 1, 1880, amount expended during fiscal year	1,381 38	
July 1, 1880, outstanding liabilities	25 00	
		1,406 38
July 1, 1880, amount available		16,240 38
Amount (estimated) required for completion of existing project		*124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1882.		*40,000 00
Amount (estimated) required for completion of project, viz, improvement between Grand Rapids and Couradis Shoals		†39,127 50
Amount that can be profitably expended in fiscal year ending June 30, 1882.		25,000 00

COMMERCIAL STATISTICS, SEASON OF 1879.

Logs and lumber.

At—	Logs scaled.		Logs sawed.	Manufactured.				Logs carried over.
				Lumber.	Laths.	Shingles.	Pickets.	
	No.	*Feet.*	*Feet.*	*Feet.*				*Feet.*
Minneapolis	825,620	145,061,800	147,416,390	157,075,711	20,467,400	52,986,000	118,272	12,000,000
Above Minneapolis	1,216	182,210	....	....	....	....	....	7,000,000
Anoka	81,985	13,677,400	27,009,850	29,355,014	4,428,350	9,003,000	....	4,622,[illegible]
Saint Cloud	1,719	271,450	2,971,250	2,973,000	550,000	2,500,000	....	65,[illegible]
Dayton	....	....	450,000	500,000	....	....	....	....
Princeton	....	....	450,000	500,000	....	....	....	....
Totals, 1879	910,540	159,192,860	178,297,490	190,403,725	25,445,750	64,489,000	118,272	23,687,[illegible]
Totals, 1878	637,041	102,198,750	187,285,700	145,319,500	23,553,200	48,128,000	....	20,975,[illegible]

FREIGHT AND PASSENGERS.

During the season of 1878 there were two steamboats plying on the Mississippi River above the falls of Saint Anthony; one plying between Minneapolis and Saint Cloud, and the other between Aitkin on the Northern Pacific Railroad and Grand Rapids, Minnesota. The latter was the only one navigating the river above the falls during the season of 1879, the former having been purchased by the Mississippi and Rum River Boom Company with the intention of remodeling and putting her into service in connection with their logging operations. But she was found inadequate, after which the machinery was sold, and the hull is now offered for sale.

On account of low-water, the steamer plying between Aitkin and Grand Rapids was unable to make more than five trips during the season, carrying up-stream, about 300,000 pounds and 120 passengers. This was but a very small part of the commerce of the river (shipped from Aitkin), the bulk of the business being done by flat-boats propelled by men with poles and ropes. There is also a large percentage of the carrying trade done by teams in winter, which would be done by boats during the season of navigation if the river was improved so as to admit of it.

It is estimated that 2,000 men went up river from Aitkin last fall, and 200 to 300

* This is the project including only the stretch of river between Saint Cloud and Minneapolis, and is offered as an estimate in case the United States orders the continuance of work upon this piece of river.

† This project was adopted following the appropriation of $15,000 made by act approved June 14, 1880.

during the haying season. The up-stream commerce of the river for the year ending June 30, 1880, is as follows:

	Pounds.
Feed and grain	3,000,000
Blacksmith's coal	60,000
Iron and hardware	100,000
Groceries and provisions	2,434,283
Salt	60,000
Total	5,654,283
Estimated value	$275,000

Furs and snake-root were brought down-stream by steamer and flat-boats to the value of $6,500.

U 3.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

No work has been done here, no funds being available for use, as the parties holding the land grant have not made the release to the United States required by the act of Congress approved March 3, 1873. The State of Minnesota should annul the grant to the parties holding the land grant and release the same to the United States. If it is determined to commence the work and carry it on, not less than $300,000 should be appropriated for the work for the fiscal year ending June 30, 1882.

Money statement.

July 1, 1879, amount available	$25,000 00
July 1, 1880, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46
Amount that can be profitably expended in fiscal year ending June 30, 1882.	300,000 00

U 4.

IMPROVEMENT OF CHIPPEWA RIVER, WISCONSIN.

Work recommenced in September, 1879, in widening and repairing the west (old) jetty, and the construction of dams at Flower-Pot Bar and the Missouri River Chute. Work was done by day labor and purchase of material in open market. The construction was as follows: 1,030 linear feet of brush and stone dams at Flower-Pot Bar, to close up a channel behind an island of that name; and 330 linear feet of brush and stone dam, to close the chute behind Little Missouri Island; also, the base of a dam was laid at Flower-Pot Cut-off, the base being 290 feet long.

The repairs consisted in strengthening the west jetty at the mouth of the river from its junction with the shore for a distance of 950 feet, and placing additional enrockment at the east jetty, where the structure had settled from the effect of the sudden irruption of water from the dams above Eau Claire and Cippewa Falls upon the base of the work. The work thus far has been of the greatest benefit to navigation, and is in generally good condition.

At the close of the season's work a rapid examination of the river was made between Eau Claire and the mouth.

Gauge-rods were established as usual, and their readings recorded and plotted.

The report of Mr. Guy Wells, overseer, giving details of the work during the season of 1879 is herewith submitted. Mr. Wells is entitled to thanks for his zealous, conscientious, and economical conduct of the work.

The river, during the months of May and June past, reached an almost unprecedented stage, the gauge at Eau Claire showing, on the 13th of June, 21.6 feet above low-water. During the latter part of June, an examination of the river in the vicinity of Eau Claire was made, and the data recorded for future reference.

The present project for the improvement of the Chippewa River, based upon the original estimate of the engineer officer in charge, dated January 30, 1875, contemplates the removal of obstructions, natural and artificial, between Eau Claire and the mouth, at a cost of $139,892.50; of which amount $64,102.50 was estimated as the cost of protecting the five high sand-banks below Eau Claire, in order to prevent the material composing the banks from being carried down the river and into the Mississippi to form sand-bars in both streams. Only those familiar with this stream can appreciate the necessity for an *adequate* appropriation for the protection of the sand-banks on the Chippewa River.

The report of the officer in charge, January 30, 1875, also contained an estimate of the cost, exclusive of locks and dams, about $50,000 for improving the channel and protecting the banks between Chippewa Falls and Eau Claire.

If the work of improving this river is to continue, it is recommended that Congress be asked to appropriate the sum named for the protection of the sand-banks on the stream, and an additional sum of $25,000 to continue the work of building wing-dams and jetties; all of which can be profitably expended during the fiscal year ending June 30, 1882.

Congress, by act approved June 14, 1880, appropriated, for improving the Chippewa River, Wisconsin—

> Continuing the improvement, ten thousand dollars; but this sum is appropriated subject to the same conditions and limitations imposed by section 1 of the act approved March 3, 1879, for the improvement of rivers and harbors, relating to said Chippewa River.

With the money appropriated by this act, and the small balance of funds on hand, it is proposed to continue the improvement as begun, by carrying the removal of obstructions up-stream from the mouth, and repairing existing works.

This work is in collection district of Minnesota. Duluth, Minn., is the nearest port of entry, at which place the revenue collected for the fiscal year ending June 30, 1880, was $4,964.51.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING CHIPPEWA RIVER, WISCONSIN.

By act approved August 14, 1876	$10,000 00
By act approved June 18, 1878	10,000 00
By act approved March 3, 1879	8,000 00
By act approved June 14, 1880	10,000 00
Total	38,000 00
Original estimate for carrying out existing project	139,892 50
Remaining to be appropriated	101,892 50

Of this amount, $64,102.50 is estimated as the cost of protecting the five high sand-banks below Eau Claire.

Money statement.

July 1, 1879, amount available	$8,061 81	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$18,061 81
July 1, 1880, amount expended during fiscal year	7,759 90	
July 1, 1880, outstanding liabilities	20 00	
		7,779 90
July 1, 1880, amount available		10,281 91
Amount (estimated) required for completion of existing project		101,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1882—		
For protecting high sand-banks	$64,102 50	
For constructing wing-dams, jetties, &c	25,000 00	
		89,102 50

COMMERCIAL STATISTICS CHIPPEWA RIVER, 1879.

248,932,000 feet lumber, at $12 per M	$2,987,184 00
135,152,000 shingles, at $2 per M	270,304 00
62,044,000 laths, at $1.25 per M	77,555 00
12,000,000 pickets, at $10 per M	120,000 00
16,000 railroad ties, at 40 cents each	6,400 00
250,000,000 pine logs, Beef Slough, at $8 per M	2,000,000 00
Cost of running out 248,932,000 feet of pine lumber, at 50 cents per M.	124,466 00
Number of steamboats plying on the river	4
Number of tons of freight carried	3,420
Number of passengers and raftsmen carried	8,730
Amount received for carrying freight and passengers	$31,746 00

Steamboats Minnie Herman and Iowa City plied between Read's Landing, Minn., and Eau Claire, Wis. Steamboat Monitor plied between Read's Landing, Minn., and Durand, Wis. Steamboat Phil Scheckel plied between Read's Landing, Minn., and Dunville, Wis.

REPORT OF MR. GUY WELLS, OVERSEER.

SAINT PAUL, *Minn., December* 1, 1879.

SIR: In accordance with your letter of instructions of September 6, 1879, I proceeded to Read's Landing to construct and repair the works at and near the mouth of the Chippewa River.

The new works constructed were the Little Missouri Dam, 330 feet in length, to close up the channel which ran behind an island of that name; the Flower-Pot Dam, 1,030 feet long, to close up a channel which ran between the right bank of the river and Flower-Pot Island; and the base of a dam across Flower-Pot Cut-off, 290 feet in length. These works are all situated about 2½ miles above the mouth of the river.

The repairs made consisted in strengthening the west jetty at the mouth of the river from its upper end down the river a distance of 950 linear feet, and of placing additional stone on the east jetty at points where it had settled.

The material was furnished mostly by James McIntire, he being the lowest bidder in open market. Work was commenced on the 16th of September, and was continued until the 20th day of November, when it was suspended. There was considerable delay in the progress of the work caused by low-water, in consequence of closing all the gates of the dams on the upper rivers between the 21st of September and the 8th of October, and after that by the high winds, which interfered with the collection of rock along the banks of Lake Pepin.

The materials used in construction and repairs were all of the best quality that could be obtained in that vicinity, the rock being of a hard and durable quality of magnesian limestone. The brush was straight and of the kind which usually grows in the bottom lands along the river in that vicinity, consisting principally of willow, yellow birch, soft maple, and elm. This brush was made into fascines from 14 to 15 inches in diameter, well choked and well tied with lath yarn, with from 4 to 5 bands to each bundle.

In all the new work the bases of the dams are from 35 to 38 feet. The bottom course was 24 feet long, of solid brush, exclusive of the tips. The next course above was 20 feet long, exclusive of tips, and laid 10 feet further up the stream than the bottom

course. This projection of 10 feet of the lower course forms an apron, which breaks up the overfall, thereby preventing the back action of the water from undermining the dam, which often occurs to dams with a narrow base and perpendicular fall on the lower side. The bottom course of brush was made into mats from 10 to 16 feet wide, floated into place and sunk by loading them with stone where the water was more than 4 feet deep. When less than 4 feet deep stone was only thrown on the tips of the brush and the mats firmly staked down. The fascines in the top course were generally laid singly and the whole loaded with stone from 18 to 20 feet wide and 1 foot deep at either end and 2 feet deep in the center, making the top of the dam from 2 to 2½ feet above the surface of low-water. The whole work was economically done, and makes a good showing for the amount of money expended. It has also accomplished the object for which it was built, to wit, the improvement of Flower-Pot Bar.

About 2,000 feet, linear, of the upper end of the west jetty was originally built with a base so narrow and on a foundation so precarious, the foundation being composed of fine sand considerably intermixed with sawdust, that it did not withstand the constant strain upon it. During high-water this strain is very great, as the whole river is confined to a space 400 feet in width between the jetties. No part of the work was swept away, but the sand was washed out underneath, which caused a settling, in places, from 3 to 5 feet. Nine hundred and fifty linear feet of this jetty was strengthened this season by widening the base, on the side removed from the river, with fascines of brush, from 12 to 20 feet, and by covering this additional width with stone to a depth of 1 to 2½ feet.

The appropriation having been exhausted, no more work could be done this season. The remainder of the west jetty should be widened and strengthened as soon as there is any money available for that purpose. Owing to the extreme width of the river at its mouth, before any government improvement was made, the stream at that point was unnavigable during all the low-water season, but now these jetties are the key to the navigation of the whole river and should be strengthened so as to insure their stability. All the lumbermen and steamboatmen unite in saying that the building of these jetties has been of more benefit every year to the commerce of the river than the whole work cost. In fact, they say they cannot now get along without them.

The total number of linear feet of new work, built this season, was 1,650. The total number of linear feet of repairs was 950, besides strengthening several weak points in the east and west jetties.

All the work done this season has consumed the following amount of materials, viz:

	Cubic yards.
For new work, stone	1,910.2
For new work, brush	2,706.6
For repairs, stone	579.1
For repairs, brush	528.7

The total amount for construction and repairs is:

	Cubic yards.
Stone	2,489.3
Brush	3,235.3

In the month of October last, according to your instructions, I made a hasty reconnaissance of the river from its mouth to Eau Claire, the head of navigation. Going up, as I did, on a steamboat, when the river was very low, I had a good opportunity to see all the obstructions, both natural and artificial, to the navigation of the river.

The natural obstructions consist of some twelve sand and gravel bars, and snags and leaning trees. These bars occur at points where the river is wide and the water spreads over a broad surface. They can easily be improved by a system of wing-dams composed of brush and stone, to contract the channel and confine the water within proper limits. The worst bars, and those which give the raftsmen and steamboatmen the most trouble every year, are generally known as the Ed Ray, Five-mile Bluff, Fred Young, Plum Island, Bear Creek, Fair Play, Hawkins' Bend, Hog Hole, Goose Lake, Rumsey, and Sevastopol Bars. In addition to the dams necessary to improve these bars, there would be several other short dams required to close up sloughs, cut-offs, and small channels behind islands.

There are a great many snags in the river, but most of them are near the shores where they can be avoided by boats and rafts, yet there are a few directly in the channel where boats and rafts are compelled to run, which are very dangerous and should be removed.

There are a great many leaning trees along both banks of the river. As the banks undermine they fall into the water, the limbs become imbedded in the sand, are very much in the way of boats and rafts, and are hard and expensive to remove. The cheapest and best way to remove them is in winter, when the river is entirely frozen over, by "falling" them on the ice, trimming off all the limbs, and cutting the bodies up into short lengths; what would not be gathered up for fire-wood would float out in the spring with the ice without doing any damage.

The artificial obstructions are boom-piers, sheer-booms, floating logs, and the refuse from saw-mills.

At the head of Beef Slough the Mississippi Logging Company have constructed in the river a line of boom-piers, over 1,300 feet in length, that diverts all logs from the main river into the slough. This boom is a great obstruction, as it is very difficult for descending rafts to pass to the right of Beef Slough Island. In addition to this, they have constructed a brush and stone dam 777 feet long, close below, and parallel with the line of their boom.

This boom and dam deflect at least one-fourth of the water into Beef Slough that would otherwise come down, and which is very much needed in the main river below.

At Round Hill, about half a mile above Beef Slough, the same company has constructed a line of boom-piers, which supports a sheer-boom to direct all the logs to the left bank, so that they will float inside the sheer-boom at the head of the slough below.

At the end of this sheer-boom is attached a swing-boom, which only leaves a passage between the end of the boom and the rocky bluff of about 130 feet when the swing is open, and when it is closed of only about 30 feet.

This is a hazardous place, as the current is very swift and the tendency is to crowd boats and rafts against the rocky shore.

There are other booms on the river which are more or less obstructions to navigation. One at Porter's, 6 miles below Eau Claire, which, when closed, spans the whole width of the river, and others near Eau Claire which are obstructions, but not to so great an extent as those before mentioned.

Some modified plan should be adopted by which the logging interest on the one part and the rafting and boat interests on the other could best be subserved without material injury or inconvenience to either party.

Floating logs are the greatest obstruction to steamboat navigation. At times, when the loggers make their "drives," the river is so completely crowded with logs that the boats have to lay up several days at a time; at other times when they are not running so thickly boats run great risks to their hulls and machinery on their account, for it is impossible to avoid striking some of them. The only way this can be remedied is to raft the logs and run them as manufactured lumber is now run.

Many of the bars heretofore spoken of are largely composed of slabs, edgings, and sawdust, the refuse of saw-mills in operation on the river above.

At the saw-mill at Menominee they have adopted the plan of grinding the slabs and edgings, *i. e.*, cutting them by machinery into small chips, which float off without doing much harm, as they are not as liable to sink and assist in forming bars.

Upon a careful examination, I find that stone can be obtained along the river more abundantly and conveniently to the work to be done than has generally been supposed. At Five Mile Bluff there is a quarry of good limestone, similar to that obtained in the bluff along the shore of Lake Pepin. Near the top of the bluff, opposite the Fred. Young Bar, I saw rock cropping out, which, I have since been informed, is of good quality. At the outlet to Dead Lake, about 14 miles above the mouth of the river, there is an inexhaustible quarry of good hard limestone, which can be very easily obtained, and will not have to be hauled more than 40 rods to the river. At Round Hill, 20 miles above the mouth of the river, there is a large quantity of sandstone, which has been used for a number of years in the boom-piers at that place, which does not deteriorate by the action of the weather. Just below Nine Mile Island, and at other points along the bank of the river, I saw plenty of sandstone, which seems to be of the same quality as that at Round Hill.

There are seven sand banks or bluffs along the river, the four largest of which are generally known as the Waubeek, Rumsey Landing, Mary Dean, and Twelve Mile Yellow Banks, whose aggregate length is about 21,000 feet, and whose average height is from 80 to 120 feet. It is estimated that not less than 775,600 cubic yards of sand from these banks slide into the river every year. They are all composed of very fine loose sand, and the face of the banks stands at a slope of about $1\frac{1}{2}$ horizontal to 1 perpendicular. In all cases the river impinges against them, undermining the base or toe of the slope, which causes the sand to slide into the river until it has again resumed its original slope.

There are no sand-bars in the river above these banks that cause any trouble, but below there are constantly shifting bars moving down at every flood until, finally, they are washed into the Mississippi River, where they cause a great deal of trouble by their never-ceasing flow. Any improvement which will prevent this sand from sliding into the river will be of great benefit not only to the navigation of the Chippewa but to the Mississippi River as well.

Very respectfully, your obedient servant,

GUY WELLS,
Overseer.

Maj. CHAS. J. ALLEN,
Captain, Corps of Engineers, U. S. A.

U 5.

IMPROVEMENT OF SAINT CROIX RIVER, WISCONSIN.

The work for the improvement of this stream has consisted in the removal of obstructions from the channel, as snags, stumps, old cribs, leaning trees, and bars, and the closing of secondary channels by means of wing-dams, the protection of caving bends, &c.

Gauge-rods were established and kept up during the year; their readings recorded and plotted.

There have been removed, during the year, 520 snags, 87 stumps, 41 cubic yards bowlders, 290 leaning trees, 4 cribs. And, in addition, 1,100 cubic yards of brush, and 2,562 cubic yards of stone quarried and placed in position, together with about 100 cubic yards of gravel. About 1,000 linear feet of shore were graded and revetted, and about 575 linear feet of dams built.

For a portion of the shore protection at Marine Bar, matresses of mill edgings were used, and, so far, they have answered very well in lieu of brush fascines. Temporary relief to navigation was also afforded by scraping bars with railroad scrapers and horses. The trade and commerce of the stream have been in the general greatly benefited by the work done to date.

A survey of the river from Taylor's Falls to Prescott, at the confluence of the stream with the Mississippi River, was made during the season, in accordance with authority from the Chief of Engineers granted in letter of the 23d of May, 1879. The report, based upon this survey, and dated January 26, 1880, is printed as House Ex. Doc. No. 40, Forty-sixth Congress, second session, and is herewith respectfully referred to.

The estimate of cost for improvement of the stream from Taylor's Falls to its mouth, based upon the survey referred to (and to supersede the estimates rendered in former reports), is placed at $60,250. The sum of $25,000 can be profitably expended during the fiscal year ending June 30, 1880.

Congress, by act approved June 14, 1880, appropriated for—

> Improving Saint Croix River, below Taylor's Falls: Continuing the improvement, ten thousand dollars, of which sum three hundred dollars, or so much thereof as, in the opinion of the engineers in charge, may be necessary, shall be expended in the improvement of the slough on the east side of said river, known as the canal between Four-Mile Island and the foot of the Saint Croix Boom.

With the remainder of funds on hand from former appropriations and the late appropriation, it is proposed to continue the work, as begun, by day labor and purchase of materials in open market.

Capt. O. F. Knapp, overseer in local charge of the work during the past year, is entitled to credit for his zeal, efficiency, and success in securing work at economical rates.

During the months of May and June past, extraordinary high-water prevailed in the Saint Croix River, one probable result of which will be that marked changes will be seen in bends, channels, and crossings upon the subsidence of the waters.

The Saint Croix River is in the collection district of Minnesota. The nearest port of entry is that of Duluth, Minn., at which port $4,964.51 of revenue were collected for the fiscal year ending June 30, 1880.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING SAINT CROIX RIVER, WISCONSIN AND MINNESOTA.

By act approved June 18, 1878*	$10,000 00
By act approved March 3, 1879†	8,000 00
By act approved June 14, 1880	10,000 00
Total	28,000 00
Amount (estimated) required for completion of existing project	50,250 00

Money statement.

July 1, 1879, amount available	$9,113 10	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$19,113 10
July 1, 1880, amount expended during fiscal year	8,923 78	
July 1, 1880, outstanding liabilities	40 00	
		8,963 78
July 1, 1880, amount available		10,149 32
Amount (estimated) required for completion of existing project		‡50,250 10
Amount that can be profitably expended in fiscal year ending June 30, 1882		25,000 00

COMMERCIAL STATISTICS.

There were three steamboats engaged exclusively in the freight and passenger business during the season of 1879, and from the statement it will be seen that the business done was large, when we take into consideration the length of river traversed—less than 60 miles.

Of the three steamboats engaged, two plied between Hastings and Taylor's Falls, and commenced running on the opening of navigation; and the other between Stillwater and Taylor's Falls, and commenced running about August 1.

The figures below were furnished by Capt. John H. Reaney, of Saint Paul, Minn., and Capt. David Hays, of Osceola Mills, Wis., under whose directions the boats were operated.

Commodities.	Number of pounds carried up-stream.	Number of pounds carried down-stream.	Total number of pounds carried.
Flour	7,490,000	810,600	8,300,600
Wheat	17,244,000	8,207,895	25,451,895
Merchandise, &c	9,343,400	2,486,000	11,829,400
Lime	868,800	1,074,300	1,943,100
Bran and feed	87,500		87,500
Barley		60,000	60,000
Oats		24,500	24,500
Salt	90,000		90,000
Total	35,123,700	12,663,295	47,786,995

Passengers carried up and down stream number 9,244.

LOGS, LUMBER, RAFTING, AND TOWING, SEASON OF 1879.

Logs.—About 202,000,000 feet of logs passed through the Saint Croix boom during the season, which at an estimated value of $8 per thousand feet would represent the sum of $1,616,000. At the boom about 300 men were employed for 100 days.

*Appropriated before adoption of existing project. See report of Capt. Chas. J. Allen, January 26, 1880, printed as House Ex. Doc. No. 40, Forty-sixth Congress, second session.

†Two thousand dollars of this amount was used in making survey of the river from Taylor's Falls to Prescott during 1879.

‡See report of survey of this stream made in 1879, under date of January 26, 1880, printed as House Ex. Doc. No. 40, Forty-sixth Congress, second session.

Lumber.—There are 10 large saw-mills on the Saint Croix River, 7 of which are located at and around Stillwater, the head of Lake Saint Croix, and engaged in the manufacture of lumber. These 7 mills cut during the season—

Lumber	feet..	83,727,820
Shingles	feet..	40,238,000
Lath	number..	27,600,000

The estimated value of these products is about $1,170,000. Expense attached to manufacturing the above, $200,000. The other 3 mills are located at Franconia, Marine, and Glenmore. The amount of their business is stated as follows:

Localities.	Lumber.	Lath.	Shingles.
	Feet.	*Number.*	*Number.*
Glenmore	6,000,000	800,000	2,000,000
Franconia	1,000,000		300,000
Marine	3,000,000	400,000	1,000,000
	10,000,000	1,200,000	3,300,000

Rafting.—This branch of business requires a large force of men, carried on, however, during only a portion of the season. The amount of lumber rafted foots up 102,000,000 feet.

Towing.—There were 12 steamboats engaged in the towing of lumber and logs to various points during the season. The amount towed was 117,000,000 feet.

U 6.

IMPROVEMENT OF MINNESOTA RIVER, MINNESOTA.

No work was done during the fiscal year ending June 30, 1880, there being no funds on hand for such. The project for the improvement of the river from its mouth to South Bend (see report, page 364, Part I, Annual Report of the Chief of Engineers for 1875) contemplated the construction of five locks and dams, and the removal of snags, overhanging trees, and drift-piles, at an estimated cost of $733,868.63, which is the existing project.

This work is in the collection district of Minnesota. The nearest port of entry is Duluth, Minnesota, at which place the revenue collected during the fiscal year ending June 30, 1880, amounted to $4,964.51.

There are no commercial statistics to report.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MINNESOTA RIVER.

By act approved March 2, 1867	$37,500
By act approved July 11, 1870	10,000
By act approved March 3, 1871	10,000
By act approved June 10, 1872	10,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874*	10,000
By act approved March 3, 1875	10,000
By act approved August 14, 1876	10,000
By act approved June 18, 1878	10,000
Total	117,500

Amount (estimated) required for completion of existing project (see page 364, Part I, Annual Report of Chief of Engineers for 1875), $733,868.63.

* Used in making survey of river.

Money statement.

July 1, 1879, amount available		$215 00
July 1, 1880, amount expended during fiscal year	$141 00	
July 1, 1880, outstanding liabilities	9 00	
		$150 00
July 1, 1880, amount available		65 00
Amount (estimated) required for completion of existing project		733,868 63
Amount that can be profitably expended in fiscal year ending June 30, 1882 (for commencement of lock and dam at Little Rapids)		75,000 00

U 7.

IMPROVEMENT OF RED RIVER OF THE NORTH, MINNESOTA AND DAKOTA.

The operations below Moorhead have consisted in dredging a channel through the clay bars to a point a few miles below the mouth of the Cheyenne River, or about 45 miles below Moorhead, so as to afford a width of water-way of not less than 60 feet and a depth at lowest stage not less than $2\frac{1}{2}$ feet.

The material removed has been generally dumped in the concave bends, forming training walls, while at the same time the deposit of material has maintained the area of cross-section of the stream after excavation, the same as it was before any work was done, thus counterbalancing almost effectually any tendency to lower the surface of the water in the pools above.

It was apprehended that the floods of this year might possibly carry away the tough, leathery clay and nullify the expected advantages, but observations thus far prove the advantages of dumping the material as has been done. As the lower river is reached more sand appears, and it is possible that some means will have to be resorted to in order to hold the dumped material in place so as to secure its permanency as wing or training walls. The result has been thus far greatly beneficial to navigation, the shipments of wheat being tenfold over those in 1878. Careful gauge-readings throughout the extent of river dredged do not show a variation of more than 1 inch in the stage of water in the pools following the excavation of the shoals. The work has been done by day labor and purchase of materials in open market, the United States owning the dredge. During a portion of the season the dredge worked day and night in order to assist commerce as much as possible. Locomotive headlights lighted the ground.

Examinations of the river were made from Frog Point to the Manitoba boundary line, in order to connect the detatched surveys made in 1877.

Early in January last, in accordance with authority from the Chief of Engineers, in letter dated the 8th of December, 1879, and in response to numerous petitions from citizens above Fargo, a party was organized to remove leaning trees, snags, &c., from the channel between Fargo and Fort Abercrombie, in order to facilitate high-water navigation between those points, large quantities of wheat awaiting shipment from Abercrombie to Fargo. The party operated on the ice, it being fitted out with tents and the necessary teams. The winter was severe; nevertheless, excellent and economical work was accomplished, and the results have this year greatly benefited that portion of the stream and the country adjacent.

The materals removed from both sections of the river for the fiscal

year ending June 30, 1880, are 57,610 cubic yards dredged material, and 219 snags and 4,151 overhanging trees.

A lock and dam at Goose Rapids, previously reported upon, would be much more satisfactory as an improvement at that point, on account of the accumulation of fall and the bed of the stream being composed of gravel and heavy bowlders, than would improvement by means of dredging and wing-dams.

The cost of this proposed lock and dam is placed at $190,000, reckoning from present prices. If this work be ordered, at least $100,000 should be appropriated with which to commence the work.

An estimate of the cost of improving the river from Breckenridge to the northern boundary line was given by Major Farquhar in his report of December 8, 1877, as follows:

1. For improving the river from Breckenridge to Moorhead for raft and flat-boat navigation	$22,663 98
2. For improving the river from Moorhead to the head of Goose Rapids	4,428 00
3. For lock and dam below Goose Rapids	219,287 99
4. For improving the river from Goose Rapids to Frog Point	32,880 20
5. For improving the river from Frog Point to the boundary line	85,338 00
Total	364,598 17

The work to consist, besides the construction of the lock and dam, in dredging, removal of obstructions, as snags, &c., and construction of dams and jetties.

Experience has shown that the cost of item 2 is altogether too low; and revised estimates of the cost of the lock and dam reduce it to $190,000.

The other items appear to be nearly correct. The officer in charge, in making the estimates, had not the means of arriving at prices that the recent development of the country now affords. The total is not, probably, far from correct.

Congress, by act approved June 14, 1880, appropriated for—

Improving Red River of the North, Minnesota and Dakota; continuing improvement, twenty thousand dollars.

No mention is made in this act of a lock and dam. It is proposed with this appropriation and the balance of funds on hand from former appropriations to continue the improvement as begun and authorized, towards the boundary line.

An additional dredging-machine would prove of much value; but the cost of another one and tender would probably approach $20,000, as there is little likelihood that another dredge can ever be constructed at such low rates as was the one built in 1878 and 1879. But little would then be left with which to operate a new machine.

The sum of $150,000 can be profitably expended upon this stream during the fiscal year ending June 30, 1882, which sum will, it is hoped, be appropriated on account of the great importance of the Red River as an avenue for the transportation of wheat and other products both within and without the limits of the United States. The amount asked for could be expended to advantage nearly in the following proportions, viz:

In removing obstructions to navigation between Breckenridge and Moorhead (Fargo is directly opposite Moorhead)	$10,000 00
In building a new dredge, and in operating it and the one now owned by the United States	40,000 00
Commencing lock and dam at Goose Rapids	100,000 00
Total that can be profitably expended between Breckenridge and the boundary line during fiscal year ending June 30, 1882	150,000 00

For details of the work done, reference is respectfully made to the appended report of Mr. Charles Wanzer, assistant engineer in local charge, whose efficiency and economical management entitle him to great credit.

The Red River of the North is in the collection district of Minnesota, of which Pembina is the port of entry. The district of Minnesota, however, embraces all of the State of Minnesota (except the waters of Lake Superior) and all of Dakota Territory, with deputy collectors at Saint Paul and Saint Vincent, Minn., and Bismarck, Dak.

The amount of revenue (duties and fees) collected at Pembina and Saint Vincent during the fiscal year ending June 30, 1880, is $16,554.35.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING RED RIVER OF THE NORTH, MINNESOTA, AND DAKOTA.

By act approved August 14, 1876	$10.000 00
By act approved June 18, 1878	30,000 00
By act approved March 3, 1879	25,000 00
By act approved June 14, 1880	20,000 00
Total	85,000 00
Original estimate for completing existing project	335,310 18
Remaining to be appropriated	250,310 18

Money statement.

July 1, 1879, amount available	$41,304 39	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$61,304 39
July 1, 1880, amount expended during fiscal year	14,200 61	
July 1, 1880, outstanding liabilities	957 36	
		15,157 97
July 1, 1880, amount available		46,146 42
Amount (estimated) required for completion of existing project		250,310 18
Amount that can be profitably expended in fiscal year ending June 30, 1882:		
For lock and dam at Goose Rapids	$100,000 00	
For building new dredge and dredging between Moorhead and boundary line	40,000 00	
For removal of obstructions between Breckenridge and Moorhead	10,000 00	
		150,000 00

COMMERCIAL STATISTICS.

Freight received and shipped during season of 1879.

By what line.	Number of pounds of freight down.	Where received.	Destination.	Number of pounds of freight up.	Destination.
Steamer Grandin	2,522,949	Fargo	Way	5,431,683	Fargo & Moorhead.
Steamer Pluck	800,000	do	do	1,200,000	do
Do	240,000	Fort Abercrombie	Fargo & Moorhead.		
Flat-boats	577,860	do	do		
Do	17,817,190	Moorhead	Winnipeg and Fort Garry.		
Red River Transportation Company.	7,040,390	Saint Vincent and Fisher's Landing.	Winnipeg	88,659	Saint Vincent
Total	28,998,389			6,720,342	

The number of passengers carried is not stated, but it is known to be large. In 1879 the Red River Transportation Company alone carried about 13,190. During the fall of 1879 there was shipped to Moorhead, from points down the river, 92,000 bushels of wheat of that year's harvest. During the year 1878, and of the harvest of the same year, there was shipped but 13,000 bushels, an increase of 79,000 bushels in 1879 over that of 1878, which increase was entirely due to the working of the United States dredge, as all other conditions were the same except that the lowest stage of water was in 1879.

It is estimated that the tonnage for 1880 will be at least double that of 1879, owing to the fact of continued high-water this season in connection with the continued work of dredging.

As a matter of general information the following estimate of the amount of wheat raised in the Red River Valley in 1879 is submitted:

	Bushels.
Clay County, Minnesota	640,000
Wilkin County, Minnesota	300,000
Polk County, Minnesota	510,000
Marshall County, Minnesota	75,000
Kittson County, Minnesota	150,000
Richland County, Dakota	150,000
Cass County, Dakota	1,300,000
Traill County, Dakota	900,000
Grand Forks County, Dakota	500,000
Pembina County, Dakota	150,000
Total	4,675,000

REPORT OF MR. CHARLES WANZER, ASSISTANT ENGINEER.

RED RIVER OF THE NORTH, *June* 30, 1880.

MAJOR: In accordance with your instructions, this report of operations conducted by me, under your supervision, on the Red River of the North, during the past fiscal year, is respectfully submitted.

The operations have consisted in the constant running and working of the dredge, an examination of the river from Frog Point (which place was the terminal point of Colonel Farquhar's survey) to the United States boundary line, a short survey on Goose Rapids in connection with the proposed location of a lock and dam, and the clearing out of snags and overhanging trees on that portion of the river between old Fort Abercrombie and Moorhead.

I.—DREDGING.

This work has been carried on in the same manner as detailed in my report of June 30, 1879, and with good general success.

The effect of the work has been beneficial in every particular, and steamboat and other river men all bear favorable testimony to the results obtained. In every case it has been found advisable to excavate so as to leave the channel (where it is naturally located) on or near the points instead of in the bends; the greater depth of water being invariably (as stated in my last report) on the side of the river convex to the axis of the stream, and this condition holds true from Fort Abercrombie above Moorhead to the gravel beds of Goose Rapids, and is entirely due to the slides from the steep clay banks touching the bends of the river.

The general plan of the work from Moorhead to the mouth of the Cheyenne River has been to excavate through the shoals a channel of at least 60 feet in width and a low-water depth of at least 2.6 feet. The work done on this part of the river does not pretend to be perfected, but was hurried through in order to render as much aid as possible to the transportation of last season's crops, and, at the same time, every yard of earth moved was in conformity to what must eventually become the settled method of improving the river. Great care was taken in all cases to measure cross-sections of the river where any work was to be done; these areas were computed and the excavated material was so deposited in the form of training dams as to contract the stream sufficiently to counterbalance the increased areas naturally obtained by dredging, thus avoiding the anticipated danger of draining the river above the work. These training dams were, in all cases, made on the side of the river concave to its axis, and the only effect of high-water this spring has been to flatten out the dams somewhat, and to deposit the material further into the bends; a fact to be desired.

Daily gauges were kept both below and above the work, and satisfactory proof that the dredging has caused no draining of the river is furnished by the fact that during the whole season the daily temporary gauges kept on the work checked at all times within $\frac{1}{10}$ of a foot with the permanent gauge-readings above the dredge at Moorhead. The work, since spring, has been entirely below the mouth of the Cheyenne River and has been thoroughly done. The excavated material has all been deposited on the banks, above low-water mark, at least 5 feet. This has required in most places that the dredge should make 2 cuts at each place to be improved, and, to avoid expensive rehandling, the excavated material has been thrown or dumped on a barge attached to the dredge, with a slide arranged on it which throws the spoil a distance in the clear of 23 feet from the side of the dredge. This slide has a slope of 1 in 3, and with the aid of water forced through a hose discharges the material as desired.

The total number of miles of river gone over by the dredge during the year is about 36, and the entire length of continuous excavation is a trifle over 5 miles. The total number of yards of earth removed during the year is 57,610.

During the season of 1879 the river was open, free of ice, and capable of navigation for a period of 208 days, and was clear again of ice on April 14 of this year. Some difficulty was experienced last year in obtaining the necessary fuel for running the dredge, at moderate prices, especially toward the latter part of the season, but this obstacle has been overcome for the present season by the purchase of some wood during the past winter which is now being saved for emergencies in the coming fall.

At this point it is but proper to mention to you the courtesies extended to the work by the steamboat men on the river, and especially by the general and subofficials of the Grandin line; they, in all cases, attesting their interest in the work by officially and personally doing everything in their power which could aid me in the conduct of affairs.

Below I submit a table of the tonnage of the river during the season of 1879, and an estimate of the amount of wheat raised in the Red River Valley during that season, and will only add that there is one fact which demonstrates the good results of the government improvements, viz: That there were shipped to Moorhead, from down the river, 92,000 bushels of wheat during the fall of 1879, of that year's harvest, as against 13,000 bushels capable of being shipped over the same portion of the river in 1878, of that year's harvest. This increase was entirely due to the working of the dredge, as all other conditions were the same excepting that the lowest stage of water was in 1879. The tonnage of the river for this year is safely estimated to be at least double of last, owing to the fact of continued high-water this season in conjunction with the continued work of dredging. The stage of water since the opening of navigaiion has been very favorable for boating purposes, the gauge below the Cheyenne River showing an average of about 6 feet above low-water and an average discharge of over 2,000 cubic feet per second, as against a low-water discharge of less than 1,000 feet.

The machinery of the dredge has proved itself equal to all that was expected of it. This season, "hog," or bearing chains, and supports to the boiler have been added to the hull.

The dredge and barges have been recalked and painted, and duplicate castings of the different parts of the machinery that were wearing out have been purchased. The dredge is now as strong and in as good condition as when it was first built.

II.—THE EXAMINATION OF THE RIVER FROM FROG POINT TO THE INTERNATIONAL BOUNDARY LINE.

The method of making this examination was the taking of channel soundings the entire distance and topographical notes. All soundings were located in reference to known points and checked on every east and west section-line of the Minnesota government land survey as they cut the river. The total distance from Frog Point to the boundary line is 98 miles by land, and 180 by river. The total fall of the low-water river surface for this distance is 49 feet, or an average slope of 0.27 foot per mile.

The results of the examination are, in general terms, given below, the river, for this purpose, being divided into five sections:

1. *From Frog Point to Grand Forks, Dakota.*—The distance between these two points is by land 22 miles and by river 35. The fall or slope for this distance is 12.8 feet, giving an average slope per mile of 0.365 foot. This section of the river is by far the best portion that is situated within the limits of the United States. The banks are high and on the Minnesota side well timbered with oak, ash, and elm for a distance of 2 miles back from the river. On the Dakota side the quality of the timber is the same, but the belt is much narrower. A line drawn from point to point of the Dakota bends would include nearly all the timbered country. The obstructions in this section of the river consist of 13 snags, 4 overhanging trees, and 1 gravel bar which would be easily removed by dredging. With the exception of this bar no place was found with a low-water sounding of less than 4 feet, and the general channel indicates a depth

of from 6 to 10 feet. The river has a varying width of from 100 to 200 feet, and differs from the section above Goose Rapids in the fact that the channel is in nearly all cases in the middle of the river. The bottom throughout the whole distance is gravelly and full of small bowlders, and consequently not liable to sudden changes.

2. *From Grand Forks to the mouth of the Turtle River.*—Grand Forks is situated in Dakota directly opposite the junction of the Red Lake River with the Red River of the North. On receiving this tributary (by far its largest) the Red River widens from 137 to 250 feet. At this point the first appearance of bars formed of clay mixed with sand takes place. This sand is all thrown out of the Red Lake River, and indicates large deposits of that material up that stream. The gauging of the Red Lake River shows a low-water discharge of 630 cubic feet per second, which about equals the low-water discharge of the Red River at Moorhead. Below Grand Forks the Red River keeps a very regular and continuous width to the boundary line, seldom being narrower than 225 feet or wider than 300 feet. The distance from Grand Forks to the mouth of Turtle River is by land 18 miles and by river 25. The slope between the two points is 6.2 feet, or an average of 0.403 foot per mile. The timber for the first 9 miles is a narrow belt on either side of the river, but for the next 9 it widens out to ¾ of a mile on the Minnesota side and to 2 miles on the Dakota side. The quality is the same as that on the upper river. The condition of the river from Grand Forks to the Turtle River bars (a distance of 11 miles) is good, with no low-water soundings of less than 4 feet. The Turtle River bars extend for a distance of 5 miles and can only be removed by dredging, as recommended by Col. F. U. Farquhar, under whose supervision detailed surveys were made of this locality in the summer of 1877, by C. J. A. Morris, assistant engineer. Wing-dams might be advantageously used to maintain a channel through these bars after it had been once dredged out. From the foot of these bars to the Turtle River, a distance of 9 miles, the character of the river is improved, only two bars of any length being found in my soundings. But in improving the river a large amount of dredging would have to be done to short bars and lumps other than those mentioned here, as only the largest and most troublesome are here considered.

3. *From the mouth of Turtle River to the mouth of the Big Salt River.*—These two points are distant from each other by land 13 miles and by river 30½ miles. Through this section of the river more shallow water is found than in any other, with the exception of Turtle River and Pelican bars. The bottom is very uneven and the transitions from 10 to 2½ feet soundings are very abrupt and numerous. None of the bars are long, but few extending for a greater distance than 500 feet. The timber belt on this portion of river is a full mile wide on both banks, that on the Dakota side being the most valuable, fire having materially injured that on the Minnesota shore.

4. *From mouth of the Big Salt River to the lower end of the Pelican Bars.*—This distance is 17 miles by land and 40 miles by river. The tributaries to this section are the Snake, Little Salt, and Tamarac rivers. The total fall of the river from the mouth of the Turtle River to the lower end of the Pelican Bars (a distance of 70½ miles) is 20.661 feet, with an average slope per mile of 0.293 foot. The first 24 miles of river below the mouth of the Big Salt are in fair condition, and but little dredging would be required to give a continuous 4-foot depth of channel. The succeeding 16 miles will require more dredging to obtain a 4-foot channel than any other portion of the lower river. There is one section of 5 miles that would require continuous dredging to furnish a greater low-water depth than 30 inches. This is in addition to the Pelican Bars, in regard to which I can furnish no additional information to the accurate notes of the survey made under Major Farquhar. The timber over this whole section is of little value and the belt becomes narrower and more nearly worthless as you approach the Canadian line.

5. *From the Pelican Bars to the boundary line.*—The river between these points is in good navigable condition, free from snags and bars, and is being constantly traversed by steamboats. The tributaries are Middle River and Two Rivers from the Minnesota side, and the Pembina River from the Dakota side, all small streams in the summer season but which discharge a large amount of water during the melting of the snow in the spring. There is at present a 3½-foot depth of channel over this section of the Red River, and no improvements of any kind will be necessary, at least until the bars and obstructions above have been removed and the effect of their removal noted. The slope of the river over this section (a distance of 28 miles by land and 48 miles by river) is only 9.333 feet, the average slope per mile being 0.194 foot.

III.—THE CLEARING OUT OF SNAGS AND OVERHANGING TREES ON THAT PORTION OF THE RIVER BETWEEN OLD FORT ABERCROMBIE AND MOORHEAD.

This work commenced on January 1, 1880, and was finished March 31, 1880. This work was done entirely on the ice and much more economically than it could have been done at any other time. I know of no place where the same amount of money could have been expended to better advantage, or furnished more relief to the settlers

in the valley. The clearing out of this portion of the river makes it fully as capable of navigation as the 30 miles of river below Moorhead was before the dredge commenced its work there.

The total number of obstructions removed during the three winter months was 4,370, of which 219 were snags and 4,151 were overhanging trees.

Last year a steamer attempted to transport wheat over this section of river but gave up the undertaking after sinking a barge load for each of the two trips it made. It is believed that they will have no further trouble on account of trees or snags during this season. From Breckenridge to Fort Abercrombie the river is free from trees as the banks have no timber on them. The river is also wide and shallow, with gravel bottom and frequent bowlders varying in size from ¼ yard to 5 cubic yards. The banks are high and the subsoil has a mixture of sand and gravel. From Fort Abercrombie to Moorhead the bottom of the river is composed entirely of blue clay and has the same characteristics as that portion below Moorhead.

IV.—A SURVEY ON GOOSE RAPIDS.

This consisted of a short survey made during the early part of November last, for the purpose of acquiring additional information in reference to the best method of improving these rapids. This survey commenced at the old proposed location of lock, and extended down the river a distance of 7 miles. As regards the necessity of a lock and dam to flow out what is known as Goose Rapids there can be no question, as the slope of the river is very considerable and the bed is full of bowlders and gravel. Dredging would be injurious on account of the great fall, unless supplemented by an extensive system of wing-dams, which would themselves prove a serious obstruction. Below is given the slopes and distances by river from the head of the rapids to the proposed dam-site.

	Distance in miles.
From Goose River to O^2, fall = 1.422 feet	1
From O^2 to P^2, fall = 1.444 feet	1.82
From P^2 to R^2, fall = 1.226 feet	1.94
From R^2 to W^2, fall = 4.563 feet	2.84
From W^2 to X^2, fall = 1.246 feet	1.74
From X^2 to Z^2, fall = 0.660 feet	1.06
From Z^2 to A^3, fall = 1.555 feet	1.82
From A^3 to proposed dam, fall = 0.550 feet	1.14

The above portion of the river would all be perfected and the slope be overcome by a lock and dam with a lift of 12 feet.

Above Goose River the slope is small and the bottom composed of clay, and the only improvement necessary is dredging.

I would merely add that from all information acquired in three seasons spent on the river, both from outside testimony and my own observation, I am convinced that a lock and dam can be built in the river proper with as much immunity and safety from floods and ice-jams as by incurring the additional expense of excavating and building through a tongue of land 45 feet high and 400 feet wide. But on account of the extreme high-water which sometimes visits this river I would recommend that the dam be a movable one, such as is in operation on the Big Kanawha River.

For the proper improvement of the various portions of the Red River of the North I would respectfully suggest the following: The building of another dredge to operate on the river below Grand Forks.

There will be an abundance of work for two dredges for ten years to come to perfect the channel, and with only one machine either the work must be slighted or one or the other portion of the river be sadly neglected. For the improvement of Goose Rapids I would recommend the building of a lock and dam.

* * * * * * *

Very respectfully submitted.

CHARLES WANZER,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Captain, Corps of Engineers U. S. A.

U 8.

SURVEYS FOR RESERVOIRS AT SOURCES OF THE MISSISSIPPI, SAINT CROIX, CHIPPEWA, AND WISCONSIN RIVERS, TO DETERMINE THE PRACTICABILITY AND COST OF CREATING AND MAINTAINING RESERVOIRS UPON THE HEADWATERS OF SAID RIVERS, WITH A VIEW TO IMPROVING THE NAVIGATION OF THE SAME.

This examination and survey was continued under provision of the following-named act of Congress, approved March 3, 1879:

For examination and surveys, for reservoirs at sources of the Mississippi, Saint Croix, Chippewa, and Wisconsin rivers, completing survey, twenty-five thousand dollars.

The details of operations being given in progress reports dated December 12, 1879, and January 15, 1880, both with maps, and sub-reports, published in House Ex. Doc. No. 39, Forty-sixth Congress, second session which reports are here respectfully referred to. Revised lists of lands liable to overflow from construction of reservoirs, also respectfully referred to, were furnished to the department on the 12th of April and the 12th of June, 1880.

Section 2, river and harbor act, approved June 14, 1880, provides:

That the Secretary of War is hereby directed, at his discretion, to cause examinations or surveys, or both, to be made, &c., and that, of the sum of $150,000 herein appropriated for surveys and examinations, the sum of $15,000 may be expended in the completion of the survey of the reservoir system on the headwaters of the Mississippi River, including Rock River in Wisconsin and Illinois.

It is proposed to continue the surveys and examination as heretofore, and in the manner detailed in the reports to date.

Money statement.

July 1, 1879, amount available	$19,353 41	
Amount appropriated by act approved June 14, 1880*	15,000 00	
		$34,353 41
July 1, 1880, amount expended during fiscal year	19,108 53	
July 1, 1880, outstanding liabilities	244 88	
		19,353 41
July 1, 1880, amount available		15,000 00

EXAMINATIONS AND SURVEYS AT THE SOURCES OF THE MISSISSIPPI RIVER, AND OF THE SAINT CROIX RIVER, IN WISCONSIN AND MINNESOTA, AND OF THE CHIPPEWA AND WISCONSIN RIVERS, IN THE STATE OF WISCONSIN, WITH A VIEW TO FEASIBILITY, COST, ETC., OF CONSTRUCTING AND MAINTAINING RESERVOIRS FOR THE IMPROVEMENT OF THE NAVIGATION OF THOSE RIVERS, AND THAT OF THE MISSISSIPPI RIVER, IN ACCORDANCE WITH ACTS OF CONGRESS OF JUNE 18, 1878, AND MARCH 3, 1879.

EXAMINATIONS AND SURVEYS AT HEADWATERS OF THE MISSISSIPPI RIVER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, December 12, 1879.

GENERAL: I have the honor to submit the following progress report pertaining to the proposed system of reservoirs at the sources of the Mississippi River.

My last report upon this subject, dated January 15, 1879, contained an estimate of $336,458.60 for the construction of seven dams to create reservoirs at Lake Winnibigoshish, Leech Lake, Mud Lake, below Ver-

* Section 2, river and harbor act, approved June 14, 1880, says this amount may be expended in the completion of the reservoir system on the headwaters of the Mississippi River, including Rock River in Wisconsin and Illinois.

million River, at Pokegama Falls, at Gull Lake, and at Pine River; also an estimate of the cost of maintenance, understanding by this the necessary repairs for the first ten years, and in addition an estimate of the cost per annum of operating the dams, cost of telegraph lines, &c. There appears no reason for changing the above estimate, excepting in so far as the increase in prices of material and labor since then. On account of the increase in prices it seems prudent to add at least 15 per cent. to the above estimates, making the total cost of the dams and appurtenances $386,927.39, and the cost of telegraph lines, including batteries, &c., $15,525. The cost of repairs for the first ten years being difficult to state with anything like accuracy, may be left as rendered in last report, as well as the cost per annum ($7,840) of operating the system of dams.

The examinations pertaining to the sources of the Mississippi during the past season have mainly consisted in meteorological observations and gaugings of the flow in the streams. Three meteorological stations have been steadily maintained, viz, one at Leech Lake, one at White Earth, and one at Red Lake, the latter point chosen as it is on the "divide" of the waters flowing into Cass, Winnibigoshish, and other lakes supplying the Mississippi and waters flowing into the Red River of the North, the annual quantity of precipitation decreasing, as may be seen by an inspection of the tables appended to this and also my last report, as we go north and west, and increasing generally as we go east and south from Red Lake. Before the establishment of these meteorological stations, no satisfactory data were at hand upon which to base estimates of the supply of water, the only method being to obtain a mean of the precipitation recorded for a number of years at military and other posts in the regions adjoining the area of country under consideration. The computation by this method compared favorably with that made by taking the low-water discharges of the streams, so far as could be done, for one of the factors. The average annual precipitation for the entire area was assumed at 25 inches, and 0'.7 assumed as the portion actually finding its way into the streams, and which could be depended upon to subserve the purposes of the reservoirs, the rest supposed to be lost by evaporation, infiltration, demands of vegetation, &c. Continuous observations at these stations for 15 months give the following:

Table of inches of rainfall from September 1, 1878, to December 1, 1879.

Locality.	September.	October.	November.	December.	January.	February.	March.	April.
Leech Lake, Minn	2.18	4.00	0.20	0.30	0.00	0.00	1.60	0.70
Red Lake, Minn	3.28	1.95	0.06	0.95	0.50	1.10	0.42	0.96
White Earth, Minn	2.23	1.75	1.03	0.54	0.10	0.51	0.42	1.08
Fort Snelling, Minn	3.53	2.14	2.60	1.19	0.17	2.36	1.20	0.64
Saint Paul, Minn	2.13	1.85	0.61	1.04	0.11	1.12	0.97	0.45

Locality.	May.	June.	July.	August.	September.	October.	November.
Leech Lake, Minn	5.15	4.50	3.81	2.05	2.18	2.35	0.25
Red Lake, Minn	2.19	4.63	3.23	2.20	0.89	2.19	0.18
White Earth, Minn	1.86	6.97	7.08	6.60	1.61	7.08	0.34
Fort Snelling, Minn	7.82	2.45	9.71	2.42	1.58	3.48	2.25
Saint Paul, Minn	7.18	1.76	9.32	2.78	2.26	2.56	1.41

It will be seen by inspection of the above table that the rainfall at Leech Lake was the same in amount in September, 1878, as in September, 1879; that in October, 1878, 1.65 inches more were recorded than for the same month in 1879; and that in November, 1879, 0.05 inch more rainfall was measured than in November, 1878. At Red Lake for the months of September, October, and November, 1878, the records show, respectively, 3.28 inches, 1.95 inches, and 0.06 inch; while for 1879, for the same months and in the order named, the records show 0.89 inch, 2.19 inches, and 0.18 inch.

The White Earth records show for September, October, and November, 1878, 2.23 inches, 1.75 inches, and 1.03 inches; while, for the corresponding months in 1879, the records are 1.61 inches, 7.08 inches, and 0.34 inch.

The mean of the rainfall at these stations for the above-named months of 1878, is 1.85 inches, while for the same period in 1879 it is 1.90 inches or about the same in value. An unusual quantity of rain is reported to have fallen at White Earth during the month of October and the records confirm the statement. For purposes of calculation of the supply it will be necessary to consider the rainfall for one year, and the period from September 1, 1878, the earliest date at which reliable observations were commenced at the White Earth, Leech Lake, and Red Lake stations is accordingly taken. The yearly amount at each of the above is—

	Inches.
At Leech Lake	24.49
At Red Lake	21.47
At White Earth	30.17
Mean	=25.37

By glancing at the map it will be seen that Cass and Winnibigoshish Lakes are nearly equidistant from the Red Lake and White Earth stations, and that White Earth, although in the watershed of the Red River, is but a short distance from Lake Itasca. Duluth, also a meteorological station, lies about 110 miles to the east and south of Lake Winnibigoshish, but its rainfall is not here considered on account of the meteorological conditions of that station. Pine River and Gull Lake are about midway between Leech Lake and Fort Ripley.

Itaska, Cass, and Winnibigoshish Lakes form part of the Mississippi proper. For the Winnibigoshish basin, it is fair to assume, for the rainfall during the year under consideration, a mean of that at Red Lake, White Earth, and Leech Lake, or, 25.37 inches. For the Leech Lake basin, we take its own record, viz, 24.49 inches. For the Mud Lake, Vermillion, and Pokegama basins, the Leech Lake record will apply, as can be seen by inspecting the map. For the Gull Lake and Pine River basins, a mean of the precipitation, as recorded at Leech Lake and Fort Ripley, is assumed, the mean being 25.9 inches. For the entire basin of the Mississippi above Saint Paul, the mean of the observations for the period from September 1, 1878, to September 1, 1879, including those of Saint Paul, gives 26.36 inches, and, including 36.23 inches at Fort Snelling, for the same period, the mean is about 28.34 inches. This, however, would be too great for the whole basin, on account of the proximity of Fort Snelling to Saint Paul.

It is apparent, then, that the value, 25 inches, assumed in my last report, as the average rainfall over the entire basin is within safe limits, and that the calculations based upon that factor need not be changed.

The determination of the available amount of precipitation, that which actually finds its way into the streams, after allowing for evaporation,

&c., is very difficult. Observations for evaporation have been made at the three meteorological stations established near the sources of the river, as well as some at Saint Paul, to determine the ratio between the evaporation from open surfaces of water and that from the marsh. These, together with accompanying observations for temperature and force and direction of wind, afford some data applicable, perhaps, to particular cases, but of little use in determining questions covering large areas of country broken by marsh, forest, streamlets, lakes, &c. Gaugings of the streams, and, especially, of the main stream, to which the whole area is tributary, if long continued, would afford means, by comparison with the total rainfall in any one year multiplied into the area of watershed, of determining, approximately, the amount of water lost by infiltration, evaporation, vegetation, &c., although not the amount due to each item. Again, some of the small lakes contained in the watershed have no visible outlets, although large portions of the rain received by them must eventually find its way into the streams.

Fortunately our meteorological observations since September, 1878, have enabled us to assign a mean value, with confidence, to the annual precipitation for the entire area so as to compare measured discharges of the river during a considerable period of time at Brainerd and Sauk Rapids, and thereby deduce the quantity of water flowing for the same period past Pokegama Falls. The area of country tributary to the river at Pokegama Falls is 3,665 square miles; the area tributary to the river above the mouth of Crow Wing River, just below Brainerd, is 7,729 square miles; and the area tributary to the river at Sauk Rapids is 13,872 square miles, the ratios being as follows: That tributary to the river at Brainerd to that tributary at Pokegama Falls, 0.475, and that at Sauk Rapids to the area above Pokegama, 0.264. And the ratio between the area tributary to the river at Sauk Rapids and that tributary at Brainerd is about 0.557. In 1875 a series of gaugings to determine the discharge was taken at Brainerd and Sauk Rapids, and at other points below, from which, together with daily observations of the stage of water, was deduced and plotted for each point a curve of discharges covering a period of time from about the middle of April to the middle of October, 1875. The measured and calculated discharge of water past Sauk Rapids, from April 15 to July 1, 1878, was 155,158,120,000 cubic feet of water; that at Brainerd for the same period, 89,562,240,000 cubic feet. Now, on the principle that if the rainfall is equal over the areas tributary to the stream at these points, the quantities of water passing the two points should be proportional to the areas, we have the proportion—

$$7729 : 13872 :: 89,562,240,000 : Q,$$

Q being the quantity of water flowing past Brainerd.

The above proportion gives for the value of Q about 160,700,000,000, a difference from the measured and calculated volume of, in round numbers, 5,500,000,000 cubic feet, a percentage of less than 4. This close agreement enables us to use the coefficients above stated for the calculation of the discharge past Pokegama from the measurements at Brainerd and Sauk Rapids. The discharge past Brainerd being for the period from April 15 to July 1, inclusive, 89,562,240,000 cubic feet, we have, after multiplying it into the coefficient 0.475, 42,542,064,000 cubic feet as the quantity passing Pokegama Falls during that time.

The discharge past Sauk Rapids for the same period being 155,158,-120,000 cubic feet, we have, after multiplying the amount by the coef-

ficient 0.264, 40,931,743,630 cubic feet. The mean of the two would be 41,751,903,840 cubic feet.

Now, prior to the 15th of April there was, as a matter of course, considerable water passing Pokegama Falls, for the discharge could not advance from zero on the 14th of April to 10,400 cubic feet on the 15th at Brainerd, nor could all the water on the last-named date have come from the water-shed immediately at Brainerd. The quantity of water just calculated came from melted snow, early spring rains, &c., the melted snow from precipitation during the winter months.

From December 10 to April 1 we may regard the water courses as ice-bound to the extent of admitting but a very slight flow of water. It would be a small estimate to allow 3,000 cubic feet per second as passing Pokegama Falls for a period of 15 days to represent the total quantity of water escaping from the watershed above Pokegama Falls from December 10 to April 15, a period of 125 days, or per second, $\frac{45,000 \times 86,400}{125 \times 86,400} =$ 360 cubic feet per second.

The reservoirs, if operated in the interest of navigation, would seldom, if ever, be opened after November 1. It would not require less than 15 days (probably 20 days) for the waters liberated from the upper reservoirs to prove of effect at Saint Paul. Hence there would be little occasion for opening the gates after November 1. An inspection of the gaugings of the streams above and at Pokegama will make it evident that we are fully justified in assuming a mean discharge past Pokegama, from November 1 to December 10, a period of 40 days, of 1,000 cubic feet of water per second. Collecting, then, this item, and the 3,000 cubic feet per second for the 15 days in April, we have to add to the quantity deduced from measurements $(40,000+45,000) \times 86,400 = 7,344,000,000$ cubic feet. And, for the entire quantity passing Pokegama Falls to be impounded by reservoirs, we have 41,751,903,840 cubic feet + 7,344,000,000 cubic feet equal to 49,095,903,840 cubic feet. This is the quantity for only five of the reservoirs.

Turning our attention now to the proposed reservoirs at Gull Lake and Pine River, we find (see report of January 15, 1879) that the supply to those reservoirs, calculated from the available rainfall, is 15,933,273,750 cubic feet. But our calculations for the reservoirs above Pokegama Falls, based upon rainfall, gives 71,052,999,653 cubic feet, as against 49,095,903,840, or about one-third more than by the calculations in this report. Making the correction and allowing for the capacities of the reservoirs, we have for Gull Lake and Pine River, in round numbers, 6,700,000,000 cubic feet more, and this, added to the quantity for the five reservoirs, gives, in the aggregate for the entire system of seven reservoirs, 55,795,903,840 cubic feet available for use by the 1st of July.

This calculation is based upon severe hypothesis; but even supposing the quantity just named to be all that can be impounded, it will give us for 100 days a little more than 6,400 cubic feet per second as an increment to the lower river after July 1. The Pine River reservoir will furnish a small surplus, 250 cubic feet per second for 100 days, its capacity not being equal to the supply, which surplus was not considered in the above aggregate.

Now, during the lowest stages of the navigation period, the discharge of the river at Saint Paul is not less than 5,800 cubic feet per second, which discharge is supplied, in small part, from the watershed tributary to Pokegama Falls, but late in the fall. We have supposed the reservoirs not to be closed after the 1st of July. The average discharge past Saint Paul prior to this low stage is in excess of 5,800 cubic feet, and

it would not probably be necessary to open the gates of the reservoirs before July 15, so that the 100 days' increment could be economized. It is claimed by some that much of the increment will be lost by evaporation and absorption. Let us assume that for 100 days the evaporation is at the rate of 0.1 inch per day, or 10 inches in all, and that there are no days of no evaporation. If the increment increases the average width of the river 200 feet (a large allowance), we would have as the loss by evaporation for that period $200 \times 5{,}280 \times 350 \times 0.83 = 306{,}768{,}000$ cubic feet, or, for 100 days, about 35 cubic feet per second. Pokegama is distant about 350 miles from Saint Paul by river.

Absorption is a more difficult factor to arrive at, but that the ground-water due to the quantity of rainfall not regarded as available for the supply of the water-courses could be so exhausted as to admit of the abstraction of any undue quantity of water from the river after receiving its increment from the reservoirs is out of the question. Besides, we have a surplus of 250 cubic feet per second from the Pine River reservoir.

We can, then, adding the 5,800 cubic feet of water passing Saint Paul at lowest stage to the 6,400 cubic feet from the reservoirs, rely upon at least 12,200 cubic feet of water past this point for 100 days of low-water navigation, and this is within 300 cubic feet per second of the quantity stated in my last report and based upon two methods of calculation, each differing from the one employed in this report.

The year 1875 was only a year of average rainfall; so was the year preceding it. The mean of the rainfall at Saint Paul, Fort Snelling, Duluth, and Pembina, for 1874, was 26.47 inches; for the same stations in 1875 it was 24.63 inches; for 1876, 27.14 inches; and for 1877, 28.61 inches.

As to the utility of 12,200 cubic feet of water per second for 100 days when navigation is generally impeded. A discharge of 3,500 cubic feet per second above Brainerd affords good navigation from that point to Grand Rapids, a distance of 180 miles; 12,000 cubic feet affords good navigation upon all the navigable stretches of river above Minneapolis, not including those portions where the worst rapids exist; lumber camps have been largely supplied by steamers plying from Brainerd northward; 12,200 cubic feet of water per second is more than double the low-water discharge past Saint Paul. The stream must be despicable whose navigation could not be assisted by doubling its lowest-water volume.

A discharge of 22,200 cubic feet per second at Saint Paul would probably correspond to a width between this point and the head of Lake Pepin of about 1,000 to 1,500 feet, excepting in some few cases where large groups of islands occur. At Fridley's Bar, above Minneapolis, a gauging in 1875 gave, for a discharge of 16,876 cubic feet, and stage of the river 3'.63 above low-water, a mean velocity of 3'.04. If we take, for a discharge of 12,200 cubic feet, the mean velocity at 3 feet, and width at 1,000 feet, we have, assuming the area of cross-section to be a rectangle, a depth of about 4 feet. But the cross-section of a stream flowing through a sandy bed does not approach the rectangular; it varies, sometimes approaching the parabolic, and sometimes the triangular. The height of a triangle, having a base of 1,000 feet, and area of 4,000 square feet $= \frac{12000}{3}$, would be 8 feet. It would certainly be within safe limits to say that, supposing the width of water surface to be as high as 1,500 feet, the ruling depth for a flow of 12,200 feet per second would be at the least 4 feet. The Rock Island Rapids, 385 miles below

Saint Paul, have been improved so as to afford a depth of 4 feet at low-water.

The head of Lake Pepin is about 55 miles below Saint Paul. The Saint Croix River flows into the Mississippi about 30 miles below Saint Paul. Its measured lowest-water volume is about 3,000 cubic feet per second, and this quantity added to the 12,200 cubic feet will increase the depth in the channel below the junction, and whatever increment can be added to that volume by the storage of water in reservoirs will add to the beneficial results.

A steady flow of 12,200 cubic feet per second above Minneapolis will render unnecessary most of the wing-dams, jetties, and other works reported as necessary for the improvement of navigable stretches above that place.

The establishment of reservoirs at the sources of the Mississippi will—

1st. Benefit navigation from Grand Rapids to the head of Lake Pepin.

2d. Render valuable, for purposes of agriculture, large tracts of land between Grand Rapids and Fort Ripley.

In my last report I discussed at length the capacities of the channels to accommodate the impounded water. An adequate appropriation to clear the river of snags and other obstructions would, besides benefiting navigation above Brainerd, facilitate the flow of water.

The report of January 15, 1879, *which should be considered in connection with this report*, recommended an appropriation of $70,000 for the erection of a dam at Lake Winnibigoshish to test the system proposed. On account of advance in prices of material and labor, I would increase that estimate to $80,000; also because the "plant" necessary would be nearly the same as that required for the construction of the entire system. No material benefits to navigation could accrue from a single dam and reservoir, and unless the entire system proposed be eventually adopted the establishment of a solitary reservoir would be useless, excepting as a demonstration of the feasibility of the reservoirs.

The Mississippi River below Saint Paul is not under my charge, but it is necessary to touch upon it, as the act of Congress ordering the examinations and surveys for reservoirs reads:

> The examination of the sources of the Mississippi River, and of the Saint Croix River in Wisconsin and Minnesota, and of the Chippewa and Wisconsin Rivers in the State of Wisconsin, to determine the practicability and cost of creating and maintaining reservoirs upon the headwaters of said rivers and their tributaries, for the purpose of regulating the volume of water and improving the navigation of said rivers and that of the Mississippi River, and an estimate of the damage to result therefrom to property of any kind.

The locations and dimensions of the several dams proposed provide, as much as possible, against any increase in surface subject to evaporation, and against undue overflow of adjoining lands. The height of the proposed dam at Pokegama Falls is limited by the height of the banks at the southern end of Pokegama Lake.

As noted above, the rainfall over the entire watershed for the months of July, August, September, and October has been left out in the calculations of the quantity to be impounded by July 1, allowing this for ordinary and low-water discharge of the river during those months. The mean discharge during these four months due to the rainfall is considerably in excess of 5,800 cubic feet.

With this report are inclosed:

1. Tracing showing proposed system of reservoirs above the Falls of Pokegama.

2. Tracing showing the locations of all the dams proposed for the sources of the Mississippi.

3. Plottings of gauge readings in 1879 at Saint Paul, Brainerd, Falls of Saint Anthony, Aitkin, Sauk Rapids, Leech Lake.
4. Report of Assistant J. D. Skinner, under date of December 1, 1879, with appended tables of rainfall, evaporation, and discharges of streams.
5. Table of lands liable to be overflowed, stating those portions that have been entered. This list is thought to be quite correct for the area above Pokegama Falls. For the Gull Lake and Pine River reservoirs they are only approximately correct.

Further examination will be made as soon as practicable, and the results reported.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. JAMES D. SKINNER, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, December 1, 1879.

MAJOR: I have the honor to submit the following report of work done on the head-waters of the Mississippi River during the current year, with a view to perfecting and completing the surveys and other work of 1874 and last year, whose object was to ascertain the practicability of establishing reservoirs thereon.

The examination of the dam-sites and all other work connected with the survey of the located system of reservoirs was so far completed last year as to leave nothing undone, except further gaugings of the Mississippi River, which the early closing of the river prevented in the fall of 1878.

These have been made with most satisfactory results, affording a complete set of high and low water gaugings, from Leech and Winnibigoshish Lakes, as far down as Aitkin on the Northern Pacific Railroad. The former gaugings were made in 1874, when the river was at a high stage, and the latter in 1878 and 1879, the river being very low, and at about the same stage during each of the latter years.

The ratio between the discharges at the different stages and at the same places, attests the correctness of the work. This, by referring to the annexed table of discharges, will be seen to be very uniform; the height above low-water, noted in the table, being taken into consideration.

The three meteorological stations, at Red and Leech Lakes and at White Earth, have been maintained, and observations for rainfall, evaporation, and temperature have been regularly taken.

The records of rainfall and temperature are unbroken since September 1, of last year, and the evaporation for each day, when no ice had formed, has also been kept.

The rainfall for the year extending from September 1, 1878, to September 1, 1879, Saint Paul being included with the above stations, gives an average of 26.36 inches, as will be seen by reference to the annexed table.

When it is considered that the summer months were unusually rainy, the average, taken last year from former reports and slightly reduced for safety, *i. e.*, 25 inches, would seem to be borne out by this year's observations.

I think there is no reason to change last year's computations.

Besides the regular observations for evaporation, which were made in the usual zinc pans with scale and micrometer screw attached, another set, during the months of September, October, and November, 1879, was carefully taken in Saint Paul, to determine the coefficient to be applied to the readings of exposed pans, to reduce them to the natural evaporation from a pond or lake, which has only its surface exposed to the action of the sun and wind, while the pan has, in addition, its bottom and outside surface so exposed. To obtain this, one pan was placed as usual and another was buried to its rim in earth, which was kept moist, and whose surface was covered with thin grass. These were regularly read and results compared.

The coefficient so obtained was 0.78; but when I reflected that the observations did not begin until September, and that the summer and spring months, when a greater difference might naturally be expected, were left out, I determined to reduce this to 0.7. Another year's full set of observations will decide whether this assumption is correct or not.

The results, this coefficient being applied to the readings in the annexed table, are for mean daily evaporation.

	Inches
*Saint Paul, September to November, 1879, inclusive	0.111
White Earth, April to November, 1879, inclusive	0.142
Red Lake, May to November, 1879, inclusive	0.112
Leech Lake, April to November, 1879, inclusive	0.087

When the different periods of time and the varying latitudes and situations of the stations are considered, I do not think the above results will be found very inconsistent. Another year's observations will, however, determine this.

In my last year's report I assumed, from what data we then had, "at least 0.1 inch" as the average daily evaporation from April 1 to November 1. The above results would seem to justify that assumption, the mean being 0.114 inch.

I annex the following tables:

I. Discharge of the Upper Mississippi River at different points for the years 1874, 1878, and 1879.

II. Monthly rainfall from September 1, 1878, to September 1, 1879, with total for year at Leech Lake, White Earth, Red Lake, and Saint Paul. Also, the same from September 1, 1878, to December 1, 1879.

III. Mean daily evaporation for 1879, from April to October, both included, from recorded readings.

IV. Observations to determine coefficient to be applied to exposed evaporator, taken at Saint Paul during September, October, and November, 1879.

There is also attached a tracing, showing the location and height of the different dams, the slope of the river, the level of the reservoirs, and the general features of the country.

The question has been asked why it is not possible to build a single dam at Pokegama Falls, which would answer the purposes of the system recommended. This question will be found partially answered in Colonel Farquhar's report of 1875, and in last year's report. It can further be safely said that the expense of such a dam, were it practicable, with the attendant dike at the southeast end of Pokegama Lake, would vastly exceed the cost of the present system. Besides, great danger at the dike would result from the construction of the dam. There an accident would be fatal, whereas any damage at the proposed dams would be insignificant and easily repaired.

Further, an attempt to flow to any extent the natural reservoirs at Leech and Winnibigoshish lakes would be an absurdity, as a glance at the accompanying profile will show. The country below is flat for the most part, and the banks of the river are low, and these when overflowed afford access to immense swamps.

With such a dam the country would be a large sea, dotted with islands for a great distance each side of the river; and, leaving evaporation out of the question, there would not be water enough from the whole watershed (in all probability) to accomplish such a result. Of course, the exact extent of such flowage can only be ascertained by further difficult and expensive surveys.

But, further, the evaporation over such a vastly increased area would be the source of an immense loss, not less than 25 inches probably, over its whole extent, while in the case of the proposed reservoirs the overflowed *surface* (see large map) is but little increased, while the *depth* is largely so. The increase of loss by evaporation is, therefore, so small as to be of no moment. (See reports.)

And, further, the damages to property that would be caused by such an overflow would be large. The lands along the river and its tributaries are owned to a large extent by lumbermen, who carry on an extensive business. Many of their pine lands would be overflowed, and whether the timber on them had been cut off or not, they would be sure to claim large damages. Their meadows would be entirely destroyed. In fact, any interest, Indian or otherwise, near the river or its tributaries, would be completely ruined, while under our system but little damage would ensue, and none whatever to any timber lands.

The above are some of the objections to a high dam at Pokegama Falls, were it practicable, and they seem to me to be unanswerable.

The final report, to which this is preliminary, with full estimates for dams, and which there has been no time to make up, will be submitted later.

Respectfully submitting the above, I am,

Very respectfully, your obedient servant,

JAMES D. SKINNER,
Assistant Engineer.

Maj. CHAS. J. ALLEN,
Captain, Corps of Engineers, U. S. A.

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*Observations for coefficient multiplied by 0.7.

Discharges of the Mississippi and Leech Lake Rivers.

Date.	Station.	Height above low water.	Area of cross-section.	Mean velocity of river.	Discharge in cubic feet per second.	Average.
1874.						
Sept. 8	Above Cass Lake	Mean high-water	482	1.074	517.0	
Aug. 22	Below Cass Lake	1.855	443	2.012	891.0	
15	First station, Leech Lake River	1.536	544	1.121	610.0	
Sept. 26	Second station, Leech Lake River	Mean high-water	1,427	0.833	1,239.0	
	Mississippi River below junction with Leech Lake River.	3.901	1,197	1.636	1,958.0	
Oct. 12	Above Pokegama Falls	2.561	849	2.914	2,474.0	
15	Below Grand Rapids	Mean high-water	731	3.454	2,525.0	
20	Below Swan River	....do	1,513	1.963	2,969.0	
27	Below Sandy Lake River	....do	1,738	1.696	2,946.0	
Nov. 3	Below Willow River	....do	1,822	2.077	3,784.0	
1878.						
Oct. 14	Below Lake Winnibigoshish	Mean low-water.	561	0.965	541.0	
16	......do		678	0.808	548.0	
Sept. 21	First station, Leech Lake River		415	0.729	303.0	
23	......do		474	0.605	226.0	
Oct. 21	Above junction Leech Lake River		342	1.821	622.0	
	Below junction Leech Lake River		672	1.354	909.0	
26	Below Vermillion River		986	0.936	922.0	
1879.						
	Below Grand Rapids:					
Oct. 15	First observation	0.4 below mean low-water.	853.3	1.161	941.0	
	Second observation	....do	853.3	1.249	1,011.0	969.0
	Third observation	....do	853.3	1.221	990.0	
	Fourth observation	....do	853.3	1.151	934.0	
	Below Sandy Lake River:					
Oct. 18	First observation	0.3 below mean low-water.	938.6	1.149	1,078.0	
	Second observation	....do	938.6	1.267	1,190.0	1150.0
	Third observation	....do	938.6	1.288	1,209.0	
	At Aitkin, Minn.:					
Oct. 20	First observation	0.2 below mean low-water.	996.7	1.738	1,732.0	
	Second observation	....do	996.7	1.748	1,742.0	1743.0
	Third observation	....do	996.7	1.738	1,732.0	
	Fourth observation	....do	996.7	1.772	1,766.0	

Monthly rainfall from September 1, 1878, to September 1, 1879, with total for year, at Leech Lake, White Earth, Red Lake, and Saint Paul, Minn.

	1878.				1879.								
	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Total yearly.
Leech Lake, Minn.	2.18	4.00	0.20	0.30	0.00	0.00	1.60	0.70	5.15	4.50	3.81	2.05	24.49
Red Lake, Minn.	3.28	1.95	0.06	0.95	0.50	1.10	0.42	0.96	2.19	4.63	3.23	2.20	21.47
White Earth, Minn	2.23	1.75	1.03	0.54	0.10	0.51	0.42	1.08	1.86	6.97	7.08	6.60	30.17
Saint Paul, Minn.	2.13	1.85	0.61	1.04	0.11	1.12	0.97	0.45	7.18	1.76	9.32	2.78	29.32
Monthly mean	2.46	2.39	0.47	0.71	0.18	0.68	0.85	0.80	4.10	4.47	5.86	3.41	......

Mean yearly rainfall, 26.36.

Monthly rainfall at Breckinridge, Minn., from January 1, 1877, to November 28, 1879, inclusive.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1877	0.03	0.01	0.30	2.08	2.81	7.44	6.54	3.36	2.50	2.85	0.29	1.17	29.38
1878	0.06	0.18	4.07	7.77	2.77	7.01	3.82	3.83	1.49	3.18	1.38	0.16	35.72
1879	0.05	0.40	0.25	1.04	5.42	2.68	3.78	2.04	2.36	0.79	*0.29	......	......

* During the first 28 days.

Monthly rainfall from January to November, 1879, *inclusive, at Saint Paul, Duluth, and Fort Snelling, Minn.*

1879.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Total for 11 months.
Saint Paul, Minn	0.11	1.12	0.97	0.45	7.18	1.76	9.32	2.78	2.36	2.56	1.41	29.92
Duluth, Minn	0.72	1.46	1.91	0.90	7.99	5.57	10.42	1.58	5.24	3.95	1.65	41.3[illegible]
Fort Snelling, Minn	0.17	2.36	1.20	0.64	7.82	2.45	9.71	2.42	1.58	3.48	2.25	34.0[illegible]

Monthly rainfall at Duluth, Minn., during the year 1878.

	Inches.		*Inches.*
January	0.55	September	4.6[illegible]
February	0.32	October	3.5[illegible]
March	1.34	November	0.[illegible]
April	5.18	December	1.[illegible]
May	2.83		
June	4.81	Total yearly	28.[illegible]
July	2.53		
August	0.52	Monthly average	2.3[illegible]

Monthly rainfall from September 1, 1878, *to November* 30, 1879, *at Leech Lake, Red Lake, White Earth, and Saint Paul, Minn.*

	1878.				1879.										
	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.
Leech Lake, Minn	2.18	4.00	0.20	0.30	0.00	0.00	1.60	0.70	5.15	4.50	3.81	2.05	2.18	2.35	0.[illegible]
Red Lake, Minn	3.28	1.95	0.06	0.95	0.50	1.10	0.42	0.96	2.19	4.63	3.23	2.20	0.89	2.19	0.1[illegible]
White Earth, Minn	2.23	1.75	1.03	0.54	0.10	0.51	0.42	1.08	1.86	6.97	7.08	6.60	1.61	7.08	0.[illegible]
Saint Paul, Minn	2.13	1.85	0.61	1.04	0.11	1.12	0.97	0.45	7.18	1.76	9.32	2.78	2.26	2.56	1.[illegible]

Daily mean of evaporation.

1879.	April.	May.	June.	July.	August.	September.	October.	Total daily mean.
White Earth, Minn	0.209	0.199	0.274	0.184	0.239	0.158	0.160	.[illegible]
Red Lake, Minn	......	0.146	0.215	0.224	0.150	0.128	0.098	.1[illegible]
Leech Lake, Minn	0.125	0.127	0.152	0.160	0.120	0.098	0.094	.1[illegible]
Wausau, Wis	......	......	......	0.161	0.145	0.125	0.065	.1[illegible]
Trout Brook, Wis	......	......	......	0.202	0.161	0.100	0.086	.1[illegible]

Observations to determine coefficient to apply to exposed evaporating pans.

1879.	September.			October.			November.		
	Sun pan.	Marsh pan.	Shade pan.	Sun pan.	Marsh pan.	Shade pan.	Sun pan.	Marsh pan.	Shade pan.
Saint Paul, Minn	0.195	0.164	0.134	0.192	0.132	0.125	0.089	0.076	0.064

Average evaporation in sun = 0.159 inches.
Average evaporation in marsh = 0.124 inches.
0.124 ÷ 0.159 = 0.78 = coefficient.

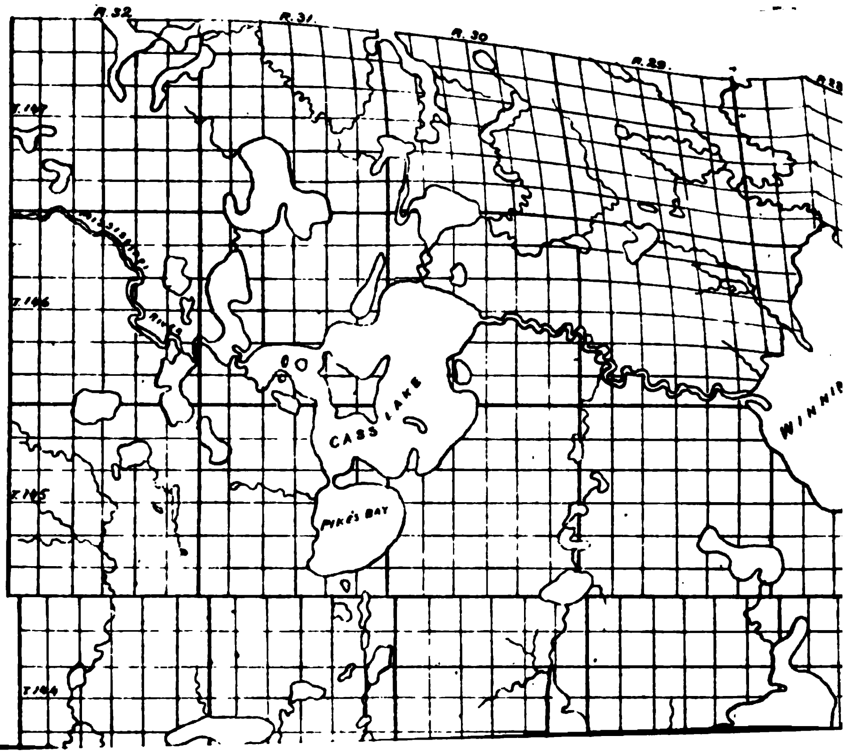
R. 32
R. 31
R. 30
R. 29
T. 147
T. 146
T. 145
T. 144
RIVER
CASS LAKE
PIKE'S BAY

Table of lands liable to be overflowed by the construction of reservoirs at the sources of the Mississippi River.

[Omitted. See House Ex. Doc. No. 39, Forty-sixth Congress, second session, pp. 13–17.]

EXAMINATIONS AND SURVEYS AT HEADWATERS OF SAINT CROIX, CHIPPEWA, AND WISCONSIN RIVERS.

ENGINEER OFFICE UNITED STATES ARMY,
Saint Paul, January 15, 1880.

GENERAL: I have the honor to submit the following progress report of the examinations and surveys at the headwaters of the Saint Croix, Chippewa, and Wisconsin rivers, made with a view to determining the feasibility, cost, &c., of constructing and maintaining reservoirs for the improvement of those streams and the Mississippi River, in accordance with the acts of Congress approved June 18, 1878, and March 3, 1879, and in continuation of my report of December 12, 1879.

Three parties were placed in the field last June, and they completed most of the necessary field work by the middle of November.

The first party, under Assistant Vine D. Simar, chief of party, and Assistants R. Davenport and G. W. Carrington, was charged with the completion of the examinations at the sources of the Saint Croix River (Minnesota and Wisconsin), begun last year by the party under Assistant Treherne.

The second party, under Asistant Archibald Johnson, chief of party, and Assistants G. O. Foss and G. M. Willis, was charged with the necessary examinations and surveys of the East and West Forks of the Chippewa River, of the Courtes-Oreilles River and Lake, and, generally, of examinations as far down as Chippewa Falls on the Chippewa River.

To the third party, under Assistant James D. Raynolds, chief of party, and Assistants W. S. Morton and J. D. Mason, was assigned the completion of the survey and examination of the headwaters of the Wisconsin River, begun late in 1878 by Assistant Charles Wanzer; and also the completion of the surveys of the North and South Forks of the Flambeau River, the main tributary to the Chippewa, begun in 1878 by Assistant J. H. Dager. These gentlemen have all acquitted themselves well of the duties with which they were charged, and are entitled to my thanks for the energy and zeal displayed by them.

These examinations were all similar in character to those described in my report of January 15, 1879, involving the running of flowage and contour lines, selection and surveys of dam-sites, lines of level connecting important points with the sea level, gauging of streams at different stages whenever possible, the collection of information relating to property liable to be damaged by overflow, and all other information attainable bearing upon the subject in hand. Several meteorological stations were established early in the season, and, although the records to date do not cover an entire year, our stock of information as regards the rainfall of this region has been materially added to.

This report is intended to be taken in connection with my report of January 15 last.

HEADWATERS OF THE SAINT CROIX RIVER.

The report of January 15, above alluded to, gives a general description of the Wisconsin watershed of the Saint Croix. The principal af-

fluents from the Minnesota watershed are the Snake, Kettle, and Tamarac rivers. From the Wisconsin side the principal affluents are the Eau Claire, Totogatic, Namakagon, Yellow, and Clam rivers.

Preliminary to the operations this year, a line of levels was run from Rush City on the line of the Saint Paul and Duluth Railroad, starting from a point at a known elevation above Lake Superior and the sea, and carried to the bench marks established last year at the Upper Lake Saint Croix, and the Totogatic and Yellow rivers; thence up the Namakagon River to the Little Pak-wa-wance, and thence across the country to the Totogatic bench marks, checking at the end very closely.

The work accomplished was as follows:

On the main Saint Croix:

Selection and survey of a dam-site above the mouth of Kettle River and gauging the discharge of the stream.

On the tributaries:

Selections and surveys of dam-sites, as follows:

One site on the Eau Claire River.

Two sites on the Totogatic River.

Two sites on the Yellow River.*

Resurvey of Yellow Lake dam-site:

Surveys of two sites on the Namakagon River.

Survey of one site on the Clam River.

Surveys of two sites on the Snake River, in Minnesota.

Kettle and Tamarac rivers, in Minnesota, were also examined, but no available sites for dams were found.

All the streams were gauged more or less for discharge in the vicinity of each selected dam-site, in order to obtain not only an idea of the amount of water flowing per second, but also an idea of the proportion of the rainfall that actually finds its way into the streams, after deducting the losses by evaporation, infiltration, absorption, &c.

The results obtained indicate that above one third of the annual rainfall actually finds its way into the streams, and calculations, based upon one-third and also upon one-fourth of the rainfall, have been made, and are submitted in the accompanying tables. In the calculations it is assumed that the reservoirs will be closed from the latter part of November to the 30th of June, although it is not likely that it will be necessary to open their gates to the full capacity before the latter part of July. As the result of our investigations both in Wisconsin and Minnesota, the above-named factors are taken to represent that portion of the annual rainfall that can be stored, from the watersheds tributary to the reservoirs, in the reservoirs, between the close of November and the 1st of July following; and these factors are used generally in all the computations.

The conditions for storing water on the Saint Croix are more favorable than I expected. The surplus—understanding by this term the excess of the supply of water over the capacities of the reservoirs—is about 60 per cent. of the entire supply derived from the watershed tributary to the stream at a point just below the mouth of Snake River. We thus have about 60 per cent. of the entire supply above this point, besides the whole of that derived from the drainage area between the mouth of Snake River and Taylor's Falls, and the entire supply from a watershed of about 1,600 square miles below the falls, to meet the de-

*These were supplementary to the three sites selected and reported upon in my last report, and are designed to retain as much as possible of the surplus water mentioned in that report.

mands of the navigable stretch below Taylor's Falls, independently of the reservoirs.

The dams found practicable from the surveys of this and last season are, if we assume one-third the rainfall for our factor:

1. At the outlet of the Eau Claire Lakes. A dam at this point, raised to a height of 12½ feet above low-water, with a reservoir capacity of 961,045,400 cubic feet, equal to 124 cubic feet of water per second for 90 days. To cost $9,635.79. The surplus is 424,511,080 cubic feet, which surplus is to be collected at some point below.

2. Below the Upper Lake Saint Croix, on the Saint Croix River, about 1 mile below what is known as the Big Dam. A dam at this point, raised to a height of 24½ feet above low-water surface, will afford a reservoir capacity of 4,698,269,800 cubic feet, a quantity of water equal to a flow of 604 cubic feet per second for 90 days, and will, in addition, take up the surplus from the Eau Claire Lakes. To cost $94,319.55.

3. On the Upper Totogatic, near the "Old Dam." A dam can be built here at a height of 12½ feet above low-water surface, affording a reservoir capacity of 1,388,605,680 cubic feet, representing a flow of 178 cubic feet per second for 90 days. No surplus. To cost $7,482.38.

4. Below Gilmore Lake, on the Totogatic River, a dam 30 feet in height will create a reservoir of 2,881,095,000 cubic feet capacity, representing a flow of 370 cubic feet per second for 90 days. The surplus from this reservoir is 2,170,209,720 cubic feet of water, to be retained at some other point. To cost $21,876.65.

5. On the Lower Namakagon, about 4 miles above its confluence with the Saint Croix River, a dam can be established to create a reservoir of 1,541,016,900 cubic feet capacity, representing 198 cubic feet per second for 90 days. (See No. 7.)

6. On the Namakagon, near Veazie's Ranche, a dam 31½ feet in height, reservoir capacity resulting 1,379,393,850 cubic feet, equal to 177 cubic feet per second for 90 days. To cost $32,762.75. The surplus at this point is 7,129,093,830 cubic feet.

7. On the Lower Namakagon, 1 mile below the confluence of the Totogatic with this stream, a dam 41 feet in height will create a reservoir, by ponding back into both the Totogatic and Namakagon rivers, of 3,082,033,820 cubic feet capacity, equal to 396 cubic feet per second for 90 days. This dam has been alluded to as No. 5, when taken with reference to the Totogatic alone. It is here considered as forming the distributing reservoir for the Totogatic and Namakagon systems, in which case its surplus is 1,055,120,740 cubic feet of water. To cost $43,610.45.

8. Mud Lake, on the Upper Yellow River. A dam 6 feet in height above low-water will create a reservoir of 396,377,420 cubic feet capacity, representing a flow of 51 cubic feet per second for 90 days. To cost $1,200. Surplus, 140,281,780 cubic feet. A sluicing dam exists at this point, and the above estimate is simply for raising and repairing it.

9. On the Yellow River, below Rice Lakes, a dam 25½ feet in height above low-water, affording a reservoir capacity of 2,474,944,500 cubic feet, can be established, with surplus of 149,806,860 cubic feet. Flow per second for 90 days, 318 cubic feet. Dam to cost $33,266.70.

10. On the Yellow River, below Yellow Lake. A dam 20 feet in height, resulting reservoir capacity 3,402,712,000 cubic feet, representing 438 cubic feet per second for 90 days, no surplus, to cost $15,403.92, can be established. This dam can be further raised 10 feet. About 4,000 linear feet of diking, to cost about $10,000, will be necessary in this case, and increased cost of dam also $10,000.

11. On the Clam River, below Clam Lake, a dam 26 feet high, afford-

ing 4,670,786,500 cubic feet reservoir capacity, with surplus of 861,681,980 cubic feet, can be built. The reservoir capacity corresponds to a flow of 602 cubic feet per second for 90 days. To cost $27,217.33,

12. On the Saint Croix proper, above the mouth of Kettle River, a dam 23½ feet high above low-water can be established, creating a reservoir of 2,709,500,000 cubic feet capacity, the volume corresponding to a flow of 349 cubic feet per second for 90 days. To cost $60,444.76. Surplus of water, 17,390,826,400 cubic feet. This dam is to retain some of the surplusage from reservoirs above it.

13. A dam on the Ground House River tributary to the Snake River, in Minnesota, to retain a portion of the surplus water of the Lower Snake, 20 feet in height, resulting reservoir capacity 1,045,440,000 cubic feet, corresponding to a flow of 134 cubic feet per second for 90 days, with surplus of 1,218,286,080 cubic feet, can be built, at a cost of $8,500.

14. At Chengwatana, on the Lower Snake River, Minnesota, a dam 13 feet in height above low-water, affording reservoir capacity of 3,703,238,000 cubic feet, corresponding to 476 cubic feet per second for 90 days, with surplusage of 13,196,648,080 cubic feet, can be established. To cost $30,000.

Dams exist at Ground House and Chengwatana, operated by private parties. They will be referred to further on.

The reservoirs at Chengwatana and above the mouth of Kettle River thus become the distributing reservoirs for the Lower Saint Croix, and as their locations are about 55 miles from Taylor's Falls, the head of navigation on the Lower Saint Croix, and about 112 miles from Prescott, where the Saint Croix joins the Mississippi, whatever increment is taken from these reservoirs to add to the normal low-water discharge of the navigable stretch of the stream will reach its destination rapidly.

Collecting from the list given above all the items of discharge from the various proposed reservoirs, we see that a quantity of water equal to a flow of 4,415 cubic feet per second for 90 days can be impounded prior to July 1, to be added to the normal discharge of the stream during the low-water period. The measured low-water discharge, as ascertained during the survey made this past season by Assistant Engineer Frederick Terry, is above McLeod's Lake, 12 miles below Taylor's Falls, 2,300 cubic feet per second, and above Prescott, mouth of river, not less than 2,800 cubic feet per second. Adding to these the 4,415 cubic feet per second. we have respectively, 6,715 cubic feet and 7,215 cubic feet per second for 90 days, or for 120 days, by a proper manipulation of the dams, 5,400 cubic feet per second passing Prescott.

We have taken in the foregoing calculations the average annual precipitation at 25 inches, and 33 per cent. of it as available for storage before July 1. I have not been able as yet to fix the value of the annual precipitation for the entire area, but believe it to be in excess of 25 inches. Much difficulty has been experienced in finding intelligent observers of rainfall. Much of the country is sandy, and at present well timbered.

Again, gravel and rock in place and some clay is met with. Major Farquhar, in his report of January 23, 1878, thought it possible that 40 per cent. of the rainfall might be regarded as available for the supply of the streams.

The area of the Saint Croix watershed above Taylor's Falls is about 6,012 square miles, equal to 167,604,940,800 square feet. If over this area but 0.7 foot be regarded as the available rainfall for the entire year, we have 117,323,458,560 cubic feet supplying the streams, and tributary to the river above Taylor's Falls. Of this quantity, we impound in reservoirs before July 1, 34,334,458,870 cubic feet, leaving a

surplus of 82,988,999,690 cubic feet. In addition, we have the 1,600 square miles of watershed below the falls to add its quota, so that from the large surplus no detriment is expected to accrue upon this basis to the navigation of the stream prior to July 1. After July 1, we have the contributions from the entire watershed.

Now, upon the basis of but 25 per cent. of the annual rainfall being available for storage prior to the 1st of July, by far the safest assumption, being certainly within limits, as shown in my report of the 12th of December, 1879, upon the Mississippi Reservoir System, we find that we can dispense with the dams at Mud Lake, and the Eau Claire lakes (see Table II), and have a total increment to the low-water discharge of 3,901 cubic feet per second for 90 days. Now, when 4,000 cubic feet of water per second pass the Dalles (Taylor's Falls), the wants of navigation on the Saint Croix are met. As not less than 1,900 cubic feet pass the Dalles at low-water, we have, by adding to this figure, 3,900 cubic feet, the sum of 5,800 cubic feet per second for 90 days, or, by proper operations of the dams for 120 days, 4,350 cubic feet per second. The amount passing Prescott for 90 days would not be less than 6,700 cubic feet per second, and for 120 days not less than 5,000 cubic feet per second. The total annual supply tributary above Taylor's Falls, upon the basis of one-fourth the annual precipitation, is 87,154,569,216 cubic feet, leaving as the surplus not held by dams 56,806,708,638 cubic feet. Now, to carry the calculations still further, the entire watershed above the Dalles is 167,604,940,800 square feet. The mean precipitation for the months of March, April, May, and June can be taken (see tables in last report) at about 10 inches. If we assume, for these 4 months, that but one-half (or 5 inches) actually flows into the streams—a safe estimate, probably, because before the first of April the ground in the higher latitudes is not prepared for active absorption, nor does vegetation assert its claims much before that time—we have as the entire supply to the streams of the watershed above the Dalles, for these months, 69,556,050,432 cubic feet of water. Now, the capacities of the reservoirs (see Table I) is about 35,000,000,000 cubic feet, and, if we take this as it is, without reduction on account of the factor $\frac{1}{4}$, we have in round numbers 34,506,000,430 cubic feet of water left, which, for the 90 days of April, May, and June, averages about 4,400 cubic feet per second passing the Dalles, the head of navigation. But the reservoirs are supposed to be closed from December 1 to July 1. We are then entitled to add to the foregoing the larger portion of the precipitation for the months of December, January, and February, and if, as is most probable, three-fourths of this quantity is available, we have, to add to that above calculated, as passing Taylor's Falls, independently of the reservoirs, in round numbers, 27,000,000,000 cubic feet. These calculations and comparisons would seem to prove the feasibility of reservoirs upon the headwaters of the Saint Croix, as adjuncts to navigation, especially as we have, in using the factor $\frac{1}{4}$, made allowance for every possible item of diminution of the water supply.

My assistants who have examined the country are of the opinion that the dams, if built and operated as above, will offer no detention to the passage of logs, as the reservoirs will all be filled before the logs are ready to pass the dams in any numbers, and the calculations seem to fully bear out this assertion. This subject will, however, be further investigated. Inspection of Tables I and II shows that a large surplus exists for many of the reservoirs, so that, if necessary to sluice the logs through before these reservoirs are filled and ready for operation, sufficient water can be spared from most of the reservoirs without infring-

ing upon the quantity to be impounded. If we assume, however, that 500 cubic feet of water per second has to be drawn in all from such reservoirs as have no calculated surplus, for as long a period even as 90 days in the spring, it can be seen, from the calculations and inspection of the tables and maps, that no perceptible effect upon the general results will obtain.

There are mechanical devices by means of which logs can be passed over dams rapidly and without waste or use of water.

The management of the dams is a matter of detail to be arranged by careful calculations and from experience gained in operating them.

The estimated cost of the proposed dams for the headwaters of the Saint Croix is $385,720.28. This is only an approximation, as borings have still to be made at many of the selected sites; the cost of materials and labor is not, for the region under consideration, thoroughly known to us; and the value of the land liable to be overflowed has not yet been taken into consideration in the estimates, for the same reason. The lists of lands liable to overflow from the construction of the proposed dams are as correct as can be made at present. The land is generally of little value. The swell or amplitude to be caused by dams placed across streams where the current is rapid has not been considered, it being impossible to calculate it with any certainty on account of the varying conditions for and at each reservoir, rapids running into and from broad expanses of water, &c. It seems best, therefore, to allow a broad margin in the case of overflow, and although the contours or flowage lines are taken as the intersections of the surface of the country by planes of true level passed through the combs of the dams, it will be safer, in the case of a portion of a section of land appearing liable to be overflowed, to assume the entire section as thus affected until, at least, actual trial proves the contrary. The township plats appended show the contours as projected under the assumption that the surface of the ponded-up water is a plane of true level; they also show the entire sections in which these contours lie. These remarks apply as well to the Chippewa and Wisconsin Rivers as to the Saint Croix.

It is proposed to construct the dams of timber, rock, and earth, as may be most easily attainable. Several short dikes, to prevent the impounded water flanking the dams, are also provided for and included in the approximate estimate for each site.

Bearing upon the existing dams owned and operated by private parties and corporations, Assistant Simar says:

The sluicing dams in Wisconsin are operated under charters granted by the State to private parties or corporations, generally for a term of 15 years.

In Minnesota, dams for sluicing logs, timber, or lumber are constructed and operated under a general license law passed by the State in 1861, which authorizes the county commissioners of the counties wherein dams are to be located to grant license, providing such dam is necessary at the point applied for, and that the land is in the possession of the parties applying therefor. Licenses may be granted for a period not exceeding 6 years, and renewed upon application. Bonds of not less than $1,000 required. Toll on logs, lumber, or timber not to exceed 6 cents per 1,000 feet, board measure, except in the case of the Snake River Dam (Chengwatana), which is allowed toll not exceeding 10 cents per 1,000 feet, board measure. Chengwatana dam was originally built and operated under a charter granted from the Territorial government.

The cost of dams, as submitted in Table I, does not include cost of damage to property, or the rights and franchises of private parties or corporations owning sluicing dams at or near the points where our selections of dam-sites were made. In regard to the latter, I think it would be a matter of small consequence, providing those parties were furnished with water for driving purposes to suit their convenience. In the case of the dam at Chengwatana, owned by Mrs. Anna Munch, of Saint Paul, a new dam at this point, built of earth and stone, would cost about $30,000; whereas the present dam, with repairs sufficient to raise the head to 13 feet, might be secured at a proba-

ble cost of $15,000 by giving the proprietors the same rights for sluicing logs and using water which they now have. This is a new dam, and would answer every purpose at this point for 10 years or more with the usual repairs which timber structures require. In submitting the cost of a dam at this point, however, I estimate $30,000, this being a safe estimate in either case. In regard to damage to property by overflow, at this time we are not provided with sufficient information to give an intelligent estimate.

In assuming one-fourth of the annual rainfall as available, dams at Eau Claire and Mud lakes will not be required.

The cost of dams on Upper Saint Croix, Rice, and Clam lakes will be materially reduced.

The list of existing sluicing dams does not comprise all existing dams on the Saint Croix watershed, but those which were found as far as examinations were extended or likely to be of use in a system of reservoirs.

HEADWATERS OF THE CHIPPEWA RIVER.

The average annual precipitation for this region is taken at 80 inches (see tables of rainfall, report of January 15, 1879). Tables I to IV, inclusive, giving results based upon one-third and one-fourth the annual rainfall, with alternate propositions for dams and reservoirs, and approximate cost thereof, as submitted by Assistant Johnson, are appended. Considering Table II—that based upon one-fourth the annual rainfall—we see that 12 eligible sites for dams have been found. They are—

1. On the Manatouish River, at the outlet of Rest Lake. Proposed dam 15 feet in height and 250 feet in length. Resulting reservoir capacity 1,840,000,000 cubic feet, corresponding to 236.62 cubic feet per second for 90 days. Surplus supply 1,847,615,360 cubic feet, to be retained in Bear Creek Reservoir. To cost $7,665.

2. On Bear Creek, about 10 miles below the outlet of the Flambeau Lakes. Proposed dam 15 feet in height and 2,500 feet in length. Resulting reservoir capacity 5,406,567,152 cubic feet. Excess of capacity over supply 2,955,591,152 cubic feet. Adding to the supply the surplus from Rest Lake Reservoir, we have 4,298,591,360 cubic feet, corresponding to a flow of 552.81 cubic feet per second for 90 days. To cost $47,500.

Taking these two reservoirs together we have surplus capacity of 1,107,975,792 cubic feet.

3. Below Park Lake, on the Turtle River. Proposed dam to be 15 feet high and 297 feet in length. Resulting reservoir capacity 620,782,720 cubic feet, furnishing for 90 days 79.83 cubic feet of water per second. To cost $9,941. Surplus water, 2,410,993,280 cubic feet.

4. At the outlet of Butternut Lake. A dam can be built at this point 10 feet in height and 336 feet in length, affording reservoir capacity of 585,446,400 cubic feet, corresponding to 75.26 cubic feet per second for 90 days, with surplus of 111,513,600 cubic feet. To cost $5,216.

5. At the outlet of Round Lake on the Upper Doré Flambeau. Proposed dam to be 10 feet in height and 170 feet in length. Resulting reservoir capacity 1,303,036,416 cubic feet, equal to 135.93 cubic feet per second for 90 days. To cost $10,550. Excess of capacity of reservoir 245,980,416 cubic feet.

6. About 2 miles below the outlet of Squaw Lake. Proposed dam to be 9 feet in height; length, 250 feet. Resulting reservoir capacity 731,808,000 cubic feet, representing a flow of 84.70 cubic feet per second for 90 days. Cost, $4,000. Excess of reservoir capacity, 73,170,800 cubic feet.

7. Below the outlet of Bear Lake, East Fork of the Chippewa River. Proposed dam 19½ feet high and 1,015 feet long. Resulting reservoir capacity 1,113,148,856 cubic feet, corresponding to 143.15 cubic feet per second for 90 days. To cost $25,925. Surplus supply 3,147,019,144 cubic feet.

8. At Little Chief Lake, East Fork of the Chippewa River. Dam to be 24 feet in height and 710 feet in length. Resulting reservoir capacity 771,332,009 cubic feet, corresponding to 99.19 cubic feet per second for 90 days. To cost $40,702. Surplus supply 232,290,391 cubic feet.

9. At the outlet of Moose Lake, West Fork of the Chippewa River. Proposed dam to be 25.7 feet in height and 1,235 feet in length. Resulting reservoir capacity 2,021,783,402 cubic feet, corresponding to 260 cubic feet per second for 90 days. To cost $45,090. Surplus supply 1,712,179,798 cubic feet.

10. Below Pa-kwa-wang Lake, West Fork of the Chippewa River. Proposed dam to be 23 feet in height and 840 feet in length. Resulting capacity of reservoir 6,193,632,598 cubic feet. Excess of capacity over supply from its own watershed 1,712,179,998 cubic feet, which can be made up from the Moose Lake surplus. This will then afford 796.50 cubic feet per second for 90 days. Cost, $55,617. The establishment of this dam will flood out the Chippewa Indian village of Pa-kwa-wang. This dam may, however, deprive a short stretch of the West Fork, below the dam-site, of the necessary quantity of water for a time for running logs. It will be seen from the tables that the surplus supply at Bear Lake Reservoir joined to that of the watershed of Little Chief Lake is, in round numbers, 3,400,000,000 cubic feet. By raising the proposed dam at Little Chief Lake a foot or more the necessary amount of water to establish the flow in the lower part of the West Fork, above alluded to, can, as reported by Assistant Johnson, be turned into the Pa-kwa-wang Reservoir, whence, as surplus water, it will feed the stretch referred to. (See A, general map.)

11. At Lac Courtes-Oreilles, proposed dam to be 5 feet in height and 260 feet in length. Resulting reservoir capacity 1,986,336,000 cubic feet, equivalent to a flow of 255.44 cubic feet per second for 90 days. To cost $1,631.

By reference to the map it will be seen that there are two large-sized lakes within this watershed that have no indicated outlets on the land maps. Time did not admit of tracing these up. It is here assumed that they lie within the Courtes-Oreilles watershed. Persons professedly familiar with the country claim that they feed Lac Courtes-Oreilles.

12. On the Chippewa River, below the mouth of Paint Creek. A dam 22 feet in height and 620 feet in length can be built here. Resulting reservoir capacity 505,336,720 cubic feet, equivalent to 64.99 cubic feet per second for 90 days. To cost $60,000.

Summing up, we have in round numbers from all the reservoirs above enumerated 2,800 cubic feet per second for 90 days to add to the normal low-water discharge of the stream. The low-water discharge of the Chippewa River at the mouth, or at the jetties, may be taken at about 2,600 cubic feet per second, and about 3,400 cubic feet just above the entrance to Beef Slough. When 4,000 cubic feet per second pass through the jetties, good navigation obtains from the mouth to Eau Claire. Adding the increment (2,800 cubic feet) from the reservoirs to the 2,600 cubic feet at the mouth, we have at least 5,400 cubic feet per second for 90 days, or 1,400 cubic feet per second more than absolutely required for purposes of navigation. If, for purposes of sluicing logs, it becomes necessary to draw upon the reservoirs before July 1, there will, at most of the reservoirs, be more water available than required. To get the quantity of water, per second, eventually reaching the Mississippi for the same period, we must consider the quantity flowing through Beef Slough, which, added to the 5,400 cubic feet, gives 6,200 cubic feet.

Touching this region, Assistant Johnson says:

Northern Wisconsin is still a vast wilderness, and, from the progress that emigration has made into that portion of the State since it was opened by the Wisconsin Central Railroad, it promises to remain so for twenty or thirty years to come. This is partially owing to the labor required in clearing up the land, but more especially to the fact that the clay soil which predominates in that region is generally impervious to water. Besides this, rocks are so common in the soil that the lands are not desirable for farming purposes. Even in swamps we invariably find bowlders and gravel at the bottom. Hence it is difficult to see where the existence of reservoirs in this region will interfere either directly or indirectly with agricultural interests.

In regard to damages to water-power for mill-sites, it is not probable that lumber will ever be manufactured in this region, for the reason that the market for lumber of the Chippewa Valley is in the Mississippi Valley, and, until we reach the vicinity of Chippewa Falls, it would be impossible to run lumber without going to unwarrantable expense.

In view of the above considerations the reservoirs will not be detrimental to the manufacture of lumber. The only cause of complaint that could arise, providing that the lumbering interests were made subservient to the interests of commerce in the Mississippi Valley, is perhaps a delay of one or two months in getting the drives to their destination at Chippewa Falls, Eau Claire, and points below. But when we consider that during winters when the fall of snow is very small the lumbering interests are embarrassed during the entire season following, as was the case on the Chippewa in 1878, a delay of a month or two is only a guarantee in the end of successful operations during each season.

The area of watershed tributary to the river at Chippewa Falls is about 5,500 square miles, the total area drained by the river being about 9,600 square miles.

The approximate total cost of the dams and dikes would be $313,837. Construction of timber, earth, gravel, and rock.

HEADWATERS OF THE WISCONSIN RIVER.

The average annual precipitation for this region is also taken at 30 inches (see tables of rainfall, report of January 15, 1879). Calculations have been made, based upon one-third and one-fourth the rainfall as factors, the results of which are given in the appended Table I, Headwaters of the Wisconsin.

The great difficulty for the Wisconsin system consists in finding storage capacity for water. But six eligible sites for dams for the formation of reservoirs of any size have been found from the surveys of this or of last season. They are:

1. On the Wisconsin, below Eagle River, at Otter Rapids. A dam can be constructed here 22 feet high, 1,300 feet in length, affording reservoir capacity of 7,389,727,488 cubic feet, corresponding to a flow of 950.32 cubic feet per second for 90 days. Surplus, 220,262,592 cubic feet. Dam and necessary diking to cost $38,113.
2. On Sugar Camp Creek, about 1½ miles from its junction with the Wisconsin. A dam can be built at this locality 12½ feet in height, 235 feet in length, to create reservoir capacity of 1,356,284,160 cubic feet, the surplus capacity being 339,884,160 cubic feet, and the quantity of water impounded for one season furnishing a supply of 130.71 cubic feet per second for 90 days. Cost of dam and diking, $8,162.
3. On the Wisconsin River, just above the mouth of Pelican. A dam can be constructed here 28 feet in height, and 800 feet in length, affording reservoir capacity of 5,153,180,527 cubic feet, corresponding to 662.71 cubic feet per second for 90 days. Surplus supply, 13,325,873 cubic feet. Cost of dam and diking, $62,929.
4. On the Upper Tomahawk. A dam 12 feet high, and 190 feet long, affording 2,226,113,036 cubic feet reservoir capacity, corresponding to

217.37 cubic feet per second for 90 days. Surplus reservoir capacity, 535,810,796 cubic feet. To cost $4,729.

5. Below Squirrel Lake, on the Tomahawk, a dam 17 feet in height, and 315 feet in length, will create reservoir capacity of 1,338,163,200 cubic feet, corresponding to a discharge of 121.52 cubic feet per second for 90 days. Surplus reservoir capacity, 393,201,600 cubic feet. Cost of dam, $17,115.

6. On the Tomahawk, below Rice Lakes. A dam can be placed here 14 feet in height, and 1,100 feet long, to create reservoir capacity of 1,043,516,880 cubic feet, corresponding to 134.19 cubic feet per second for 90 days. Surplus supply, 5,821,539,120 cubic feet. To cost $24,930.

Dams at Lac Vieux Desert and Twin Lakes can be established to hold the surplus at Otter Rapids.

On account of the forced locations for these dams so near the extreme sources, the reservoir capacity produced by several of them is in excess of the supply, although the total surplus from the area tributary to the proposed reservoirs is estimated at 4,500,000,000 cubic feet.

The quantities above given are based upon one-fourth the rainfall as a factor.

It is claimed by some and denied by others, who profess familiarity with the Wisconsin River, that a site for a high dam exists below the junction of the Tomahawk and Wisconsin rivers, and that a reservoir can be created of sufficient capacity to retain the surplus waters from the reservoirs above. It is of importance to settle this question, and it is proposed, as soon as an opportunity occurs, to send a small party to examine the ground instrumentally, and also to further examine Pelican River.

With the reservoirs now found practicable we can deliver, in round numbers, 2,300 cubic feet per second for a period of 90 days. This quantity, considered as an increment to the discharge of the Mississippi River at the mouth of the Wisconsin, would be too small to prove of benefit to the Mississippi below that point. The surplus water from the areas tributary to the proposed reservoirs is so great that we can dismiss the question of any diminution of the 2,300 cubic feet on account of evaporation from surfaces of reservoirs, or *en route* to the lower river, or by absorption *en route*.

Lagrené (*Cours de navigation intérieure*) states that the rate of evaporation from water in a state of agitation compared with that from the surface of a body of water at rest has been reported as 65 to 45. Of course this proportion varies with localities and change of conditions. The discharge of the impounded water will in some cases upon the Wisconsin (and also upon the Saint Croix and Chippewa rivers) pass over rapids of greater or less expanse. But any such items of diminution sink into insignificance when compared with the surplus, not only from the areas above the reservoirs, but from the watershed generally. The matter is merely touched upon here to show that it has received attention.

A small portion of the surplus waters may be held by converting Lac Vieux Desert and Twin Lakes into reservoirs by the construction of dams at an estimated cost of $15,000 to $20,000.

The entire area of the Wisconsin River watershed is about 11,800 square miles. The total area above the proposed reservoirs is about 1,410 square miles, and the area of watershed tributary to the river above Portage, the head of navigation, is, after deducting that from which the reservoirs would draw their supply, about 6,800 square miles. So that no injurious effects are expected to accrue to navigation upon

the Lower Wisconsin at any time owing to the impounding of water before July 1. As to any interruption to the operations of log-driving before the gates can be opened, or as to the quantities of water, if any, necessary to be expended from the reservoirs before July 1 for sluicing logs, I am not at this moment prepared to speak decidedly.

The advantage of driving logs with sufficient supply of water will, doubtless, be considered by lumbermen as compensation for any short delay. Whether an increment of 2,300 cubic feet per second for 90 days, added to the normal discharge of the stream during a period of 90 days, when low-water ordinarily occurs, will be of material benefit to the navigable stretches below the proposed dams or not is a matter in regard to which I would respectfully defer to the officer in charge of the improvement of the Wisconsin River.

The total estimated cost of the proposed dams, including those at Vieux Desert and Twin Lakes, is, as given by Assistant Raynolds, $170,978. This estimate is only an approximate one, it being difficult to arrive at close estimates for the region under consideration, and especially so in the absence of borings at selected dam-sites.

Damage to property from overflow, caused by the proposed dams, has not been arrived at, but it will be, it is thought, slight, as the land is generally of little value. Lists of lands liable to overflow, as complete as can be made at present, are appended.

EFFECT UPON THE NAVIGATION OF THE MISSISSIPPI RIVER OF ALL THE RESERVOIRS, INCLUDING THOSE AT THE SOURCES OF THE MISSISSIPPI.

Collecting the various items of discharge, we find that we can control, from the proposed reservoirs at the sources of the Mississippi, sufficient water to insure a steady flow of, at the least, 12,200 cubic feet per second, past Saint Paul, for 100 days (see my report of December 12, 1879); and from the Saint Croix, for the same period, 6,000 cubic feet per second. The sum of these gives about 18,000 cubic feet per second for 100 days.

A gauging of the Mississippi River, in the fall of 1878, taken several miles below the mouth of the Saint Croix, under the direction of Major Farquhar, Corps of Engineers, reduced to the low-water of 1864, showed 10,100 cubic feet of water per second passing that point, or but little more than one-half of the quantity that can be assured for 100 days, as above stated. Now, carrying our quantity forward to the mouth of the Chippewa, neglecting the area of watershed tributary to the river between the Saint Croix and the mouth of the Chippewa, we have at the latter point 4,860 cubic feet more per second for 100 days, or, in all, 22,860 cubic feet per second for 100 days. And passing the mouth of Beef Slough we have about 23,660 cubic feet per second for the same period; in round numbers, 24,000 cubic feet.

A gauging of the Mississippi River at Winona, about 30 miles below Beef Slough, under direction of Major Farquhar, in 1878, reduced to the low-water of 1864, showed 11,190 cubic feet of water per second passing that point, or less than one-half of the quantity that can be assured from the combined operations of the proposed reservoirs at the sources of the Mississippi, Saint Croix, and Chippewa rivers, added to the normal low-water flow of these three streams; 24,000 cubic feet per second for a width as at Winona would afford not less than 5 feet in the channel.

We have thus far neglected the smaller watersheds between the mouth of the Saint Croix and the mouth of the Chippewa. By exam-

ining the table of watersheds, Appendix X, we see that between the mouth of Beef Slough and the mouth of the Wisconsin is a watershed of about 8,000 square miles. The precipitation over this area for the months of July, August, September, and October may be taken as averaging 12 inches. Assuming ¼ as a factor, we have as additional quantity of water just above the Wisconsin an average of 5,400 cubic feet for 120 days, or omitting the 20 days, in all a little more than 29,000 cubic feet for 100 days; and just below the mouth of the Wisconsin (adding the low-water flow of that stream to the 2,300 cubic feet from its reservoirs), at least 36,000 cubic feet per second for 90 days. As to what can best be accomplished on the Mississippi River below Saint Paul by these volumes the officer in charge of that stretch of river is better prepared to answer.

The figures that have been taken as representing the low-water flow of these streams are much below their *average* discharges between July 1 and the middle of November.

Many of the reservoirs will have, when considered only with reference to one season, large surplus capacities. But, on the other hand, there may be expected to compensate seasons when the full supply will not be drawn upon. In this case, the water can accumulate and fill them to their maximum capacities.

As regards the effect upon the quantity of rainfall annually by deforesting and rewooding extensive areas of country, I will, without referring to meteorological observations made by myself, refer to those tabulated in my report of January 15, 1879. By an inspection of these tables it will be seen that the Saint Paul records cover seven consecutive years, viz., from 1872 to 1878, inclusive.

The annual rainfall is for—

SAINT PAUL, MINNESOTA.

	Inches.		Inches.
For 1872	28.86	For 1876	23.67
1873	33.74	1877	22.80
1874	35.57	1878	22.09
1875	30.66		

FORT SNELLING, MINNESOTA.

For 1837	24.02	For 1853	20.47
1838	27.72	1854	26.59
1839	21.19	1855	24.75
1840	23.17	1856	22.62
1841	21.67	1857	32.09
1843	23.70	1868	32.21
1844	30.24	1869	34.53
1845	25.34	1870	26.07
1846	26.10	1871	21.78
1847	21.80	1872	17.02
1848	23.18	1873	18.71
1849	49.69	1874	18.56
1850	25.50	1875	27.12
1851	23.42	1876	28.32
1852	15.07	1877	19.48

FORT RIPLEY, MINNESOTA.

For 1850	35.32	For 1862	14.39
1852	34.52	1863	17.20
1853	26.12	1867	30.34
1854	18.49	1868	28.03
1855	23.55	1871	34.02
1856	25.33	1872	34.77
1858	19.81	1873	40.78
1859	26.00	1875	28.17
1860	30.61	1876	19.48
1861	32.42		

FORT RIDGELY, MINNESOTA.

	Inches.		Inches.
For 1855	34.78	For 1860	16.97
1856	23.20	1861	21.89
1857	38.38	1862	30.05
1858	22.52	1863	18.17
1859	32.85	1864	14.46

DULUTH, MINNESOTA.

For 1873	38.42	For 1876	31.86
1874	39.86	1877	32.19
1875	25.13		

FORT PEMBINA, DAKOTA.

For 1872	17.19	For 1875	11.60
1873	14.05	1876	24.70
1874	11.88	1877	22.04

FORT ABERCROMBIE, DAKOTA.

For 1861	23.39	For 1868	18.90
1862	11.38	1870	20.47
1863	13.40	1871	15.27
1864	16.85	1872	27.83

FORT WINNEBAGO, WISCONSIN.

For 1837	31.34	For 1841	28.45
1838	27.88	1842	24.51
1839	28.95	1843	22.80
1840	27.12		

FORT HOWARD, WISCONSIN.

For 1836	37.64	For 1839	31.28
1837	40.55	1840	33.57
1838	37.56	1851	31.47

The felling of timber has been actively carried on over the greater portions of Minnesota and Wisconsin for the past thirty years, having been especially active for the past fifteen years, and the records do not indicate any decrease in the annual precipitation due to deforesting the country. Nor does there appear from inspection of the monthly means of rainfall contained in the report above referred to any logical connection between the felling of trees and the distribution of the rainfall by seasons. It would be premature, however, to express any decided opinion in this matter, as nothing but long continued observations can furnish the means of arriving at conclusions in the case. Meteorological conditions vary for different areas.

Cultivation of the ground may, it is much easier to see, affect the flow of water into the streams, sometimes conducing to a rapid increase in the volumes of the streams, and again retarding the flow so as to maintain a more equable stage, depending upon surface and subsurface formation, &c. Long continued observations of the daily stand of water in the principal affluents and the main streams, as well as frequent gaugings of the flow of water in each, afford the only means of arriving at any conclusions of value upon this point.

We have ascertained as far as possible, to date, the extent of property liable to overflow or to be affected by the construction of the proposed dams. Doubtless some interests will be benefited by the creation of the reservoirs; others, again, will be injured. Many of the dams proposed will, if constructed, develop water-power.

The examinations necessarily covered more ground than was at first anticipated. Much of the information that had been furnished the parties by persons professing familiarity with the country was found, upon

examination of the ground, to be worthless. The greater part of the field work has been accomplished, but reconnaissances of several possible sites ought to be made. In addition, borings at most of the selected dam-sites upon the Saint Croix, Chippewa, and Wisconsin rivers should be made in order that estimates of the cost of foundations may be rendered with more exactness than can be done at present. Meteorological observations should be continued in Wisconsin for another year at least, and the main streams and affluents more thoroughly gauged. The estimated cost of the examinations and observations is $10,000.

I would especially invite attention to the valuable reports of Assistants Simar, Johnson, and Raynolds, herewith submitted.

Assistant J. D. Skinner has continued in immediate charge of the parties in the field, contributing largely to the successful operations of the season.

I am much indebted to Mr. J. P. Frizell, principal assistant, and to Assistant Engineers Guy Wells and C. J. A. Morris in the matter of estimates for and details of dams, &c.

It will be seen from the foregoing that if the plan of reservoirs as adjuncts to the navigation of the Upper Mississippi, Saint Croix, Chippewa, and Wisconsin be adopted, good results for each stream, and ultimately to the main Mississippi, can best be realized by the construction of all the dams proposed. The question of expediency, however, is one with which the engineer generally has little to do, his office commonly being to present facts and figures.

In order to operate the dams to best advantage they should all come within telegraphic communication with a central office. The cost of telegraph-lines, including batteries, &c., for the several systems, is estimated as follows:

For the Upper Mississippi	$15,525
For the Saint Croix	12,750
For the Chippewa	9,000
For the Wisconsin	9,000

These estimates may be reduced as private telegraph-lines multiply and where consolidation can be effected in the case of several dams being separated from each other by but a few miles.

The cost of maintaining the dams, &c.—understanding by this the repairs—is not easy to state. From the best information to date, I assume that, if well built, 15 per cent. of their original cost will suffice for the first ten years.

The cost of operating a dam would probably average $800 per annum. The dam-tenders could perform the duties of the telegraph operators and meteorological observers also. Some reduction in expense of operating dams might be made by consolidation. A system of gauge-rods at prominent points on the streams and the employment of gauge-readers would also be necessary. Probable cost per annum, $1,500.

RECAPITULATION OF ESTIMATES.

*Sources of the Mississippi.** (See report of December 12, 1879.)

Dams	$386,927 39
Telegraph-lines, &c	15,525 00
Total	402,452 39
Maintenance the first ten years, 15 per cent	60,367 85
Cost of operating dams, per annum	5,600 00
Gauge-rods and observers, per annum	375 00

Sources of the Saint Croix.

Dams	$385,720 28
Contingencies of engineering, 10 per cent	38,572 02
Telegraph-lines, &c	12,750 00
Total	437,042 30
Maintenance first ten years, 15 per cent	65,556 34
Cost of operating, per annum	6,400 00
Gauge-rods and observers, per annum	375 00

Sources of the Chippewa.

Dams	$313,837 00
Contingencies of engineering, 10 per cent	31,383 70
Telegraph-lines	9,000 00
Total	354,220 70
Maintenance first ten years, 15 per cent	53,133 10
Cost of operating dams per annum	5,600 00
Gauge-rods and observers, per annum	375 00

Sources of the Wisconsin.

Dams	$170,978 00
Contingencies of engineering, 10 per cent	17,097 80
Telegraph-lines	9,000 00
Total	197,075 80
Maintenance first ten years, 15 per cent	29,561 37
Cost of operating, per annum	4,000 00
Gauge-rods and observers, per annum	375 00

To accompany this report are appendixes *a* to *x*, inclusive, and the following-named maps and plots:

One general map of the Saint Croix watershed.
One general map of the Chippewa watershed.
One general map of the Wisconsin watershed.
One plotting of gauge-readings at Taylor's Falls, Saint Croix River, 1879.
One plotting of gauge-readings at Stillwater, Saint Croix River, 1879.
One plotting of gauge-readings at Eau Claire, Chippewa River, 1879.
One plotting of gauge-readings, mouth of Chippewa River, 1879.
One set colored plats, lands liable to overflow, Saint Croix River.
One set colored plats, lands liable to overflow, Chippewa River.
One set colored plats, lands liable to overflow, Wisconsin River.
In all, 24 appendixes and 10 maps and plots.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX *a*.

SAINT CROIX RIVER.

REPORT OF MR. VINE D. SIMAR, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, December 30, 1879.

SIR: I have the honor to submit the following preliminary report of surveys and examinations of the sources of the Saint Croix River, with tracing of general map

showing watershed, location of dam sites, capacity of holding-grounds, and such information as could be shown in the time allotted to this report. The work consisted in the examination of those portions of the Saint Croix watershed, of which previous examination had not been made, to ascertain if any and what amount of water can be held by reservoirs in addition to the results of last year, and the cost of constructing dams, with as much information of value as possible. Work was commenced June 4, by sending a detached party into the field in charge of Assistant R. Davenport, with instructions to run a base line of levels from Rush City on the Saint Paul and Duluth Railroad, across and up the valley of the Saint Croix River to Upper Lake Saint Croix, making connections with the work done last year, and leaving benchmarks at prominent points to facilitate future operations. Upon the completion of this work it was thought best to run a line of levels up the Namakagon River from Veazie's Ranch to Little Puckwawance; this was done by Assistant Davenport, who then reported to the main party at Rice Lakes, June 28.

The main party left Saint Paul June 12, via the North Wisconsin Railroad to Granite Lake, at that time the terminus of the line, and about 20 miles distant from Yellow River crossing. This distance was made by teams through the Big Woods and over execrable roads. Upon arriving at Yellow River, the 14th, work was started from this point by running a line of levels up the river to Mud Lake. This lake has an area of 2¼ square miles, and can be made available for holding any small surplus not held at more eligible points. A line of levels was run down the river from Yellow River crossing to Rice Lakes, at which point a dam site was selected, and survey made, to obtain, if possible, holding-grounds for the surplus not held on Yellow River.

The dam site affords a rise of 25 feet above low-water. This was taken as the proposed height of dam, and contour lines run to that elevation. After completing the survey of the dam site, transit-lines were run around the entire holding-grounds, and as near as practicable to the line of flowage. A line of levels followed, and frequent cross-section lines were run out, to accurately determine the flowage line. Intermediate lines were run with compass where required. The location of the dam-site is the best that could be found. It has a length of 500 feet on top, while the valley is about 250 feet wide at a rise of 15 feet. The banks of the stream are composed of sand and fine gravel. The bed of the river consists of sand and gravel to a depth of 10 to 15 feet. At this depth there appears to be a deposit of clay and gravel; this, however, could not be accurately determined with the appliances with which we were provided. In addition to the dam proper, there will be required, at different points, about 1,500 linear feet of dike, of an average height of 13 feet. Our surveys show the following results on Yellow River:

Area of watershed, 321½ square miles	8,962,905,600 square feet.	
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		6,274,033,9[illegible]
Capacity of reservoirs:		
Yellow Lake, survey of 1878 ... cubic feet	3,402,712,000	
Rice Lake, survey of 1879 ... do	2,474,944,500	
Total holding capacity		5,877,656,5[illegible]
Leaving a surplus of		396,377,4[illegible]

which can be held on Mud Lake with 6 feet rise of dam, thus leaving no surplus on Yellow River.

From reservoirs, full, can be furnished for 90 days, per day, 69,711,488 cubic feet; per second, 807 cubic feet.

CHARACTER OF THE STREAM.

Yellow River is termed a constant stream, from the small range in the natural rise and fall of the river throughout the year, which varies from 1¼ to 3¼ feet, owing to locality. Springs and spring creeks are numerous on the upper portions of the stream. The valley is generally narrow, being from 200 to 800 feet in width, although in some localities it widens into tamarac marshes of considerable extent. The first banks have a general elevation of 15 feet above low-water, running back into high broken ridges covered with white, Norway, and Jack pine. There are some rapids on the upper portion of the river. Little or no stone or bowlders are found until reaching the rapids below Yellow Lake, which are almost continuous to the mouth of the stream.

Our next point of operations was on the Namakagon River, about 32 miles above the mouth, near Veazie's Ranch. This is the most available point for holding-grounds above the mouth of Totogatic River and below Namakagon Lake. It was

not deemed advisable to make a survey at the latter point, there being only 43 square miles of watershed to supply a reservoir which gives by one-third the annual rainfall, about 800,000,000 cubic feet. This amount can be held by the sluicing-dam in operation at the outlet of Namakagon Lake.

The dam site at Veazie's affords a height of 30 feet. Contour lines were run to this elevation, the work being done in a similar manner as at Rice's Lakes. Upon completing the survey, it was found that the holding-grounds were not as large as had been anticipated. They comprise: Whalen's Lake and the valley of Whalen's Creek on the north; Trout Brook on the south; the valley of the Namakagon to the mouth of Spring Brook, and the valleys of Bean Brook and Jordan Creek between these points. These valleys are small, sloping to higher grounds on either side, rendering the holding capacity of the reservoir small.

Dam site.—The banks are high at this point, the length of dam being 330 feet, to which must be added 700 linear feet of dike, with an average height of 6 feet on the north side of the river. The river banks are sand and light soil; the bed of the stream is of sand and fine gravel to a depth of 6 to 10 feet. Careful soundings were taken to determine, if possible, the nature of this substratum, which was thought to be clay and gravel or some equally hard material. Upon completing our work at this point, examinations were continued down the river. A line of levels was run down the river to Moore's Station, 1¼ miles below the mouth of the Totogatic, to connect with the base line of levels run from Rush City. Observations were frequently made to determine the slope of the river. Arriving at the mouth of McKenzie Brook, a line of levels was run up the creek to McKenzie Lake to ascertain, if possible, how to utilize this and the lakes above for holding-grounds on the Namakagon River, as it was thought possible to flow these lakes by putting a dam across the Namakagon, a short distance below the mouth of the creek. This was found to be impracticable, there being a rise of 33 feet from the mouth of the creek to the first lake, a distance of 2¼ miles. Hasty examinations were made in the vicinty of Webb Creek and Lake and at the mouth of the Totogatic River to find, if possible, sufficient holding-grounds to justify us in making a survey at this point, the surplus on the Namakagon being very large. Subsequent surveys were made with the following results: By putting a high dam across the Namakagon, 1 mile below the mouth of the Totogatic River, a large holding-ground can be obtained and the supply be drawn from either of the two named rivers. Forty feet were taken as the rise of dam. Transit and level lines were run up the Totogatic a distance of 10 miles, to the mouth of Chicorg Creek, and up the Namakagon to Casley Brook, 12 miles above the dam site. From these base lines numerous intermediate, transit, compass, and stadia lines were run out, as occasion required. The area of holding-grounds is about 7¼ square miles, comprising 10 miles of the valley of the Totogatic, 12 miles of the valley of the Namakagon, Webb Creek Valley, Webb Lake, and some small lakes, with adjacent marshes and low lands. Our surveys show the following results on the Namakagon River:

Area of watershed above lower dam site = 648 square miles = 18,065,203,200 square feet.		
Annual rainfall		25 inches.
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		12,645,642,240
Capacity of reservoirs:		
Veazie's	1,379,393,850	
Mouth of Totogatic drawn from Namakagon	3,082,033,820	
Total holding capacity		4,461,427,670
Leaving a surplus of		8,184,214,570

From reservoirs full, for 90 days, can be furnished, per day, 49,571,418 cubic feet; per second, 573 cubic feet.

The surplus on the Namakagon may be reduced about 800,000,000 cubic feet by utilizing the holding-grounds at Namakagon Lake.

Dam site is located 4 miles above the mouth of the Namakagon and 1 mile below the mouth of the Totogatic, at the head of a stretch of rapids. At this point, the high banks on either side approach to within 600 feet before breaking away into the valley of the Saint Croix, thus affording a very good site for a dam. The banks are composed of sand and gravel. The river bed is of the same material, to a depth of from 2 to 20 feet, proceeding from the right to the left banks. The substratum at this depth is a clay and gravel hard-pan. Upon gaining this information, it was deemed that a 40-foot rise of dam would not be impracticable. The river at this point has a width of 200 feet, and the valley, at 40-foot rise, a width of 600 feet.

CHARACTER OF THE COUNTRY.

The source of the Namakagon is Lake Namakagon, situated in the southeast corner of Bayfield County, and near the divide in the watersheds of the Chippewa River and Lake Superior. They consist of numerous lakes, and extensive cedar and tamarac marshes. From Namakagon Lakes to Veazie's the river is generally narrow and rapid, stretches of rapids over native trap-rock being frequent. There are also several vertical falls of from 2 to 4 feet. The banks are high on either side, stretching away into high broken ridges and sand barrens, covered with the various kinds of pine; hemlock and birch being found on the upper portions of the river. From Veazie's to the mouth the river is from 100 to 200 feet wide, and in some cases attaining a greater width in passing over gravel bars. There are several sharp pitches and rapids, principal of which are "Little" and "Big Bull" Rapids, and "Dupee Flats." The river is navigable for small boats, such as bateaux and canoes, at a stage of 1 foot above low-water. The slope of the river is about 5 feet per mile.

Leaving Moore's Station, August 2, a line of levels was run from near Antoine Gordon's place through to Eau Claire Lakes, where a survey was made and holding-grounds found for the surplus on the Upper Saint Croix not held by dams. A dam site was selected at the outlet of first Eau Claire Lake and above the old sluicing dam. A rise of 12 feet was obtained for dam site, which has a length of 220 feet. The banks consist of sand; the river bed being apparently sand and gravel. The holding-grounds comprise first and second Eau Claire Lakes, Cranberry Lake, and several marshes.

Results on Upper Saint Croix:

Comprising that portion of the watershed above dam site below Lake Saint Croix in section 35, town 44 north, range 13 west, 290 square miles	8,084,736,000 square feet.	
Annual rainfall		25 inches.
Available rainfall		0.7 feet
		Cubic feet.
Supply from watershed		5,659,315.200
Capacity of reservoirs:		
Lake Saint Croix ....cubic feet..	4,698,269,800	
Eau Claire Lakes ....do....	961,045,400	
Total capacity of reservoirs		5,659,315.200

leaving no surplus.

From reservoirs full, for 90 days, can be furnished, per day, 62,881,280 cubic feet; per second, 728 cubic feet.

Second Eau Claire Lake has an elevation of 1,122 feet above sea-level. The lakes are surrounded by high banks. On the west they are gently rolling, while on the east and south the country is high and broken, the ridges being covered with pine, hemlock, and hard woods. Frequent outcroppings of the copper-bearing rock of Lake Superior are found. After completing this work, a line of levels was run through to Blackburn's Crossing on the Upper Totogatic, thence up the river to the sluicing dam located in section 12, township 42, range 10 west, and about fifty miles above the mouth. A cross-section was made about fifty feet above the site now occupied by a dam. From this point sufficient examinations were made to determine the holding capacity of the valley and marshes above, and that a 12-foot dam will hold the supply of the water-shed above this point. Our line of levels was continued through to Little Puckwawance, where connection was made with the line of levels run from Veazie's to this point by Assistant Davenport in the earlier part of the work. The dam site has a length of 360 feet. The banks are clay and sand. A ledge of trap-rock exists about 1 foot below the river bed, and above this rock is a deposit of loam, clay, and bowlders. We are enabled to show the following results on the Totogatic River:

Area of watershed, 389 square miles	10,844,697,600 square feet.	
Annual rainfall		25 inches.
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		7,591,288,320
Capacity of reservoirs:		
Upper Totogatic	1,388,605,680	
Gilmore Lakes	2,881,095,000	
Mouth of Totogatic:		
Drawn from Totogatic River	1,541,016,900	
Total holding capacity		5,810,717,580
Leaving a surplus of		1,780,570,740

From reservoirs full, for 90 days, can be furnished, per day, 64,563,478 cubic feet; per second, 746 cubic feet.

The source of the Totogatic River is about 15 miles above the upper dam site and between Eau Claire and Namakagon lakes. The country is high and precipitous, especially on the north, toward the Totogatic-oance, the principal tributary of the Totogatic River. Through this region vast ranges of hills and cliffs extend for miles. Ledges of trap-rock, loose trap, and bowlders, are found in profusion.

Timber is of dense growth and consists of white pine; black, white, and yellow birch, hemlock, hard maple, elm, cedar, balsam, beech, and other species of smaller growth. There is a tradition among the Indians of the lake region that "Wani-Bajou," the aboriginal devil, inhabits this wilderness, which territory is considered by them as sacred to him.

Dam site.—The dam site is about 2 miles above the "Big Falls" (a vertical fall of 10 feet, over ledges of trap-rock). From this point to "Blackburn's," 10 miles distant, rapids are almost continuous, the stream not being navigable for boats of any kind. A canoe voyage was made from Blackburn's to the mouth of Totogatic for the purpose of exploring that portion of the river. The stage of water was about 1 foot above low-water, but two low for purposes of navigation. Our progress over rapids which were frequent was necessarily slow and frequent portages were necessary. Rapids are frequent and especially so from the dam site near Gilmore Lake to the outlet of Driving Lake. The valley is narrow, being from 200 to 600 feet wide, with low bottoms, generally on one side, while the river runs near a high bank opposite. The stream is very crooked, doubling back and forth on its downward course. Arriving at the mouth of Totogatic after two days' voyage, a survey was made in this locality, of which previous mention has been made.

Upon the conclusion of this work a detached party, in charge of Assistant R. Davenport, was sent down the Namakagon and Saint Croix rivers with instructions to make examinations of the Upper and Lower Tamarac rivers for holding-grounds. Of these streams Assistant Davenport says: "The Upper Tamarac enters the Saint Croix about 1 mile below the Wisconsin State line. The stream is small with a probable discharge of 15 cubic feet per second at ordinary stage of water. The valley passed through is generally wide and low, abounding in poplar and hard wood bottoms and tamarac marshes. The stream is very crooked, with frequent small rapids, and has a fall of 4 feet or more per mile. The only locality apparently suited for a dam site is on the upper portion of the stream, where several small creeks come together, but, the area of watersheds is so small as to make it of no practical value. The Lower Tamarac enters the Saint Croix some 10 miles below; is the larger of the two and has a probable discharge of 20 cubic feet per second. The valley is narrow, with high pine ridges on both sides. The stream is very crooked, with frequent small rapids and high banks. No suitable site for a dam or holding-ground is known on this stream."

The remainder of the party came through to Yellow Lake by land, where examination was made of the low grounds in the vicinity of Bass Lake, to ascertain the amount of dike, if any, necessary to raise the height of proposed dam at Yellow Lake. It was found that about 4,000 feet of dike, with the additional height of dam, would be required.

A line of levels was run from Marshland to Clam Lake, at which point a dam-site was chosen and survey made on a basis of 20 feet rise of dam. The holding-grounds are large, and by increasing the height of dam to 25 feet, which may be done with safety, the supply of the watershed may be held at this point.

Dam-site.—The site selected is one-half mile below the outlet of Clam Lake, and a short distance above Chase's sluicing-dam. Length of dam, 560 feet; height of dam, 25 feet.

The banks consist of sand, which appears to be the only material in this immediate vicinity. The river bed is composed of sand to a depth varying from 3 to 20 feet, at which points soundings indicate a hard material, supposed to be clay and gravel. This, however, can only be determined by borings being made at this point.

RESULTS ON CLAM RIVER.

Area of watershed, 283¼ square miles	7,903,526,400 square feet.
Annual rainfall	25 inches.
Available rainfall	0.7 foot.
	Cubic feet.
Supply from watershed	5,532,468,480
Capacity of reservoir at 25 feet rise of dam	4,670,786,500
Surplus	861,681,980

From reservoirs full for 90 days can be furnished, per day, 51,897,628 cubic feet; per second, 602 cubic feet.

The river above Clam Lake consists of the North and South Forks, each discharging about the same volume of water. At Clam Falls, the South Fork breaks over trap-rock ledges. Upon reaching the foot of the rapids below the falls the slope of the river is light, being about 2 feet per mile. The valleys of the streams are wide, with bottoms from 2 to 5 feet above low-water, extending from one-fourth to one-half mile on either side. Timber consists of hard and soft wood. A dense growth of underbrush covers the bottom lands. Below the dam-site the river is very crooked, with no rapids, except one stretch just above the mouth.

The surveys on Clam River completed our operations in Wisconsin, except some further examinations on the Saint Croix in the vicinity of the mouth of Snake River.

At the conclusion of this work we proceeded to Pine City, on Snake River, about 14 miles above the mouth. Chenwatana dam is located on Snake River, two miles below Pine City, and just below Cross Lake. The dam is owned and operated by Mrs. Anna Munch, of Saint Paul. It is maintained wholly for sluicing logs, and furnishing water sufficient for driving them over Snake River Rapids and into the Saint Croix River. In case of low-water in the Saint Croix, water can be furnished by this reservoir to drive the logs to Taylor's Falls and to the lake below.

This is the most available point on Snake River for a reservoir. The dam consists of crib-work and stone, and has one 24-foot gate, six 14-foot gates, and one 8-foot gate, all of the Parker patent, and constructed for 9½ feet head. At this head the holding capacity of the reservoir is, in round numbers, one and seventh-tenth billions cubic feet. By raising the head to 13 feet, which our examination proved feasible, the capacity will be more than doubled, or increased to three and seven-tenths billions cubic feet. More than 13 feet head cannot well be carried, as it would necessitate the construction of long dikes to protect the city from a partial overflow, and the overflow of valuable improved farming lands. Thirteen feet head will flow up the river to Brunswick, a distance of 24 miles, thereby flowing out Millett's Rapids—a short distance below Brunswick—which have a fall of 3½ feet in 1½ miles.

Examinations were continued up Snake to Ann and Knife rivers; small amounts of water may be held on these streams at sites which are now occupied by sluicing-dams. The amount held by these dams would probably not exceed 600,000,000 cubic feet, as the holding-grounds are small in every case.

The streams are narrow and rapid; the valleys admit of no holding-grounds, while the lakes are small, with low banks. Native trap-rock abounds in the bed of the streams. Examination of Ground-House River was also made. This is the largest tributary of Snake River, and enters 1 mile below Brunswick and just above Millett's Rapids. By putting in a 20-foot dam just below the forks of Ground-House in section 7, township 38 north, range 24 west, there can be held upward of 1,000,000,000 cubic feet. Aside from this reservoir no holding-grounds of consequence were found.

RESULTS ON SNAKE RIVER.

Area of watershed above Chengwatana, 982 square miles		27,376,588,800 square feet
Annual rainfall		25 inches.
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		19,163,612,16[illegible]
Capacity of reservoirs:		
Ground-House	1,045,440,000	
Chengwatana	3,703,238,000	
Total holding capacity		4,748,678,000
Surplus		14,414,934,16[illegible]

From reservoirs full for 90 days can be furnished, per day, 52,763,088 cubic feet; per second, 610 cubic feet.

Both sites are now occupied by dams. The probable cost of repairs and raising the head of the dam on Ground-House will be about $8,500.

The head of Chengwatana dam might be raised to 13 feet, at a cost of $15,000. From Chengwatana to the mouth of Snake there is an average fall of 11 feet per mile over nearly continuous rapids of trap-rock, ledges, and bowlders.

Examinations were made on Kettle River and tributaries, with little hopes of finding holding-grounds for reservoir. There are small holding-grounds on Moose, Willow, and Pine rivers, but in each case too small, or situated too near the source of the stream, to be of value.

We found no holding-grounds on Kettle River. The river has an average fall of 6 to 8 feet per mile, over sharp pitches and long stretches of rapids. The banks are

high and precipitous and the valley narrow, admitting of no holding-grounds in itself. The ridges on either side are high and well supplied with pine and hard-wood timber. Examination of the Saint Croix Valley was made below the mouth of Snake and Kettle rivers for the purpose of obtaining holding-grounds for a portion of the large surplus on those streams. This was found to be impracticable, the valley being comparatively narrow, with bottoms rising rapidly to bluffs on either side. The slope of the river is very large, especially above the mouth of Snake. At the head of Kettle River Rapids on the Saint Croix, 2¼ miles above the mouth of Kettle River, a cross-section for dam-site was made. Length, 2,500 feet; height of rise, 25 feet. The banks at this point consist of clay and sand, with trap-rock ledge for foundation. The slope of the river above the dam-site is about 2¼ feet per mile.

This enables us to show the following results on the Saint Croix River above the dam-site at the head of Kettle River Rapids (called, in Table No. 1, Lower Saint Croix):

Area of watershed, 2,962 square miles		82,575,820,800 square feet.
Annual rainfall		25 inches.
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		57,803,074,560
Capacity of reservoirs:		
Upper Lake Saint Croix	4,698,269,800	
Eau Claire Lakes	961,045,400	
Upper Totogatic	1,388,605,680	
Lower Totogatic	1,541,016,900	
Gilmore Lakes	2,881,095,000	
Veazie's (Namakagon)	1,379,393,850	
Lower (Namakagon)	3,082,033,820	
Mud Lake	396,377,420	
Rice Lake	2,474,944,500	
Yellow Lake	3,402,712,000	
Clam Lake	4,670,786,500	
Head of Kettle River Rapids	2,709,500,000	
Total holding capacity		29,585,780,870
Surplus		28,217,293,690

We can then show the following results on the Saint Croix River as far as examinations have been made:

Watershed of the Saint Croix River above the mouth of Snake River, 5,012 square miles =		139,726,540,800 square feet.
Annual rainfall		25 inches.
Available rainfall		0.7 foot.
		Cubic feet.
Supply from watershed		97,808,578,560
Capacity of reservoirs:		
Dam-site at the head of Kettle River Rapids, and above that point	29,585,780,870	
From Snake River	4,748,678,000	
Total holding capacity		34,334,458,870
Leaving a surplus of		63,474,119,690

From reservoirs full for 90 days can be furnished, per day, 381,493,987 cubic feet; per second, 4,415 cubic feet.

From surplus for 270 days can be furnished, per day, 230,814,617 cubic feet; per second 2,671 cubic feet.

This comprises all of the Saint Croix River watershed above the mouth of Snake River. From this showing we hold only 35 per cent. of the supply from one-third of the annual rainfall taken at 25 inches, thus leaving only 65 per cent. of the supply as available throughout the remainder of the year.

Appended hereto is a tabulated statement of the discharge of the different streams taken at dam-sites and other points, with stage of water when taken as near as could be determined from information at hand.

A list of existing sluicing-dams is also attached, showing such information as we were able to gain in regard to age, cost, capacity, and effect on the river below.

We show, also, a list of elevations at different points on the Saint Croix and tributaries, with slope per mile between points, and on the whole length of river examined.

Those elevations marked approximate were arrived at, as near as possible, from other level lines, slopes, and such other information as we were able to obtain. They are put in to assist in giving a general idea of the country gone over.

We also give tables showing the watershed above each dam in square miles and square feet, supply by each one-third and one-fourth the rainfall capacity of reservoirs, and amounts furnished per day and second for a period of ninety days.

TABLE V.—(SUMMARY.)

	Sq. miles.	Square feet
Watershed of Saint Croix above the head of Kettle River Rapids	2,962	82,575,820,80
Watershed of Snake above Chengwatana	982	27,376,588,80
Total watershed tributary to reservoirs	3,944	109,952,409,60
		Cubic feet
Supply by one-third rainfall = 0.7 foot		76,966,686,72
Capacity of proposed reservoirs		34,334,458,70
Surplus		42,632,227,50
	Sq. miles.	Square feet
To which add watershed of Snake below Chengwatana and the Saint Croix from mouth of Snake to dam above	35	975,744,00
Watershed of Kettle River	1,033	28,798,387,20
Total watershed above mouth of Snake not tributary to reservoirs	1,068	29,774,131,20
		Cubic feet.
Supply by one-third rainfall = 0.7 foot		20,841,891,84
Add former surplus		42,632,227,50
Total surplus at mouth of Snake		63,474,119,62

From reservoirs, full, can be furnished for 90 days, per day, 381,493,985 cubic feet; per second, 4,415 cubic feet.

This comprises all the watershed of the Saint Croix River and tributaries above the mouth of Snake River.

TABLE VI.

	Sq. miles.	Square feet.
Watershed of the Saint Croix above head of Kettle River Rapids	2,962	82,575,820,80
Watershed of Snake above Chengwatana	982	27,376,588,80
Total watershed tributary to reservoirs	3,944	109,952,409,60
		Cubic feet.
Supply by one-fourth rainfall = 0.52 foot		57,175,252,99
Capacity of proposed reservoirs		30,347,860,57
Surplus		26,827,392,414
	Sq. miles.	Square feet.
To which add watershed of Snake below Chengwatana and the Saint Croix from mouth of Snake to dam above	35	975,744,00
Watershed of Kettle River	1,033	28,798,387,20
Total watershed above mouth of Snake not tributary to reservoirs	1,068	29,774,131,200
		Cubic feet.
Supply by one-fourth rainfall = 0.52 foot		15,482,548,224
Add former surplus		26,827,392,414
Total surplus at mouth of Snake		42,309,940,638

From reservoirs, full, can be furnished for 90 days, per day, 337,198,448 cubic feet; per second, 3,901 cubic feet.

This comprises all the watershed of the Saint Croix River and tributaries above the mouth of Snake River.

TABLE VII.

Existing sluicing dams on the Saint Croix River and tributaries.

	Head.	Width of gateway.	Holding capacity.	Number days driving.	Gate discharge.	Approximate cost of dam.	When built.	Remarks.
	Ft.	*Feet.*	*Cubic feet.*		*Sq. ft.*			
Dam at Namakagon Lake.	9	30	1,500,000,000	20	180	$1,800	1869	Generally fills to 6 feet head in eleven months. Filled to 9 feet head once in nine years.
Totogatic Dam	9	30	1,250,000,000	....	....	1,180	1860	Kept in good repair and might be utilized for holding its capacity. Only one of consequence on this stream.
Saint Croix Dam ...	10	100	....	2½	450	....	1871	This discharge raises water 1 foot on Kettle River Rapids 50 miles below.
Clam Lake Dam ...	8	36	700,000,000	....	....	1,230	1877	Dam in good condition; head cannot be raised except at great expense.
Mud Lake Dam....	7½	30	475,000,000	7 to 10	....	800	......	With slight repairs can be utilized to hold its capacity.
Hector Dam	7½	30	....	2	....	800	......	Holding grounds small.
Rice Lake Dam....	10	30	700,000,000	....	....	2,200	1878	Built in 1878. The head might be raised to 15 feet.
Yellow Lake Dam .	10	57	1,400,000,000	....	....	1,800	1869	In poor condition; needs rebuilding.
First Eau Claire Dam.	8	48	500,000,000	....	....	1,500	1867	Of no account until rebuilt.
Third Eau Claire Dam.	8	48	500,000,000	....	....	....	1872	In good condition.
Puckwawance Dam	....	......	....	....	....	....	......	Holding grounds small.
Knife River Dam ..	8	40	....	6	162	1,500	......	Raises Snake River 15 inches.
Ann River Dam, 1 .	6	40	....	6	....	1,000	......	Holding grounds small.
Ann River Dam, 2 .	8	24	....	6	....	1,000	......	Do.
Ground House Dam	11	26	300,000,000	6	88	2,000	......	Raises Snake River one-half foot.
Upper Snake River Dam.	10	32	....	....	....	....	......	Holding grounds small.
Mud Creek Dam...	6	16	1,500,000,000	....	....	500	......	Supply small; raises Snake River 3 inches.
Chengwatana Dam.	9½	116	1,689,819,200	......	396	6,300	1877	Raises Saint Croix River 1.6 feet at Taylor's Falls.

The sluicing dams in Wisconsin are operated under charters granted by the State to private parties or corporations, generally for a term of fifteen years.

In Minnesota, dams for sluicing logs, timber, or lumber, are constructed and operated under a general license law passed by the State in 1861, which authorizes the county commissioners of the counties wherein dams are to be located to grant license, providing such dam is necessary at the point applied for, and that the land is in the possession of the parties applying therefor. Licenses may be granted for a period not exceeding six years, and renewed upon application. Bonds of not less than $1,000 required. Toll on logs, lumber, or timber, not to exceed 6 cents per 1,000 feet board-measure, except in the case of the Snake River Dam (Chengwatana), which is allowed toll not exceeding 10 cents per 1,000 feet board-measure. Chengwatana Dam was originally built and operated under a charter granted from the Territorial government.

The cost of dams as submitted in Table I, does not include cost of damage to property or the rights and franchises of private parties or corporations owning sluicing dams at or near the points where our selections of dam-sites were made. In regard to the latter I think it would be a matter of small consequence, providing those parties were furnished with water for driving purposes to suit their convenience. In the case of the dam at Chengwatana, owned by Mrs. Anna Munch, of Saint Paul, a new dam at this point built of earth and stone would cost about $30,000; whereas the present

dam, with repairs sufficient to raise the head to 13 feet, might be secured at a probable cost of $15,000, by giving the proprietors the same rights for sluicing logs and using water which they now have. This is a new dam and would answer every purpose at this point for ten years or more with the usual repairs which timber structures require. In submitting the cost of a dam at this point, however, I estimate $30,000; this being a safe estimate in either case. In regard to damage to property by overflow, at this time we are not provided with sufficient information to give an intelligent estimate.

In assuming one-fourth of the annual rainfall as available, dams at Eau Claire and Mud lakes will not be required, and the cost of dams on Upper Saint Croix, Rice, and Clam lakes will be materially reduced.

The list of existing sluicingd ams does not comprise all existing dams on the Saint Croix watershed, but those which were found as far as examinations were extended or likely to be of use in a system of reservoirs.

Thanks are due Mr. Charles Bean, of Hersey, Bean & Brown, Stillwater, for valuable information; also to Messrs. Munch Brothers, of Saint Paul, for like favors. To Assistants R. Davenport and G. W. Carrington, much credit is due for faithful and intelligent co-operation in the early accomplishment of the work.

Very respectfully, your obedient servant,

VINE D. SIMAR,
Assistant Engineer.

Maj. CHARLES J. ALLEN,
Captain, Corps of Engineers, U. S. A.

APPENDIX *b*.

CHIPPEWA RIVER.

REPORT OF MR. ARCHIBALD JOHNSON, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, December 24, 1879.

MAJOR: I have the honor to submit the following report of surveys made by me, under your direction, on the sources of the Chippewa River, for the purpose of estimating the capacity of reservoirs and the cost of creating and maintaining the same.

Pursuant to your instructions, I proceeded on the 9th of June to Chippewa Crossing, on the line of the Wisconsin Central Railroad, and arrived there on the 11th. This was made the initial point of the survey.

The first work to be done was to select a point on the grade at the south end of the railroad bridge, which was afterwards ascertained to be 920.5 feet above Lake Superior, or 1,522.5 feet above the sea-level, and from there run to Bear Lake two sets of levels, taking elevations of the water in the river at the head and foot of rapids whenever it was practicable to reach the river.

Besides this, a reconnoissance was made of the river. We started down the river on June 13. The river from Chippewa Crossing to the bend in section 34, township 42 north, range 2 west, consists of a series of small rapids, the fall varying from 1 to 3 feet. At the bend there is about 1 mile of sluggish water, but from there to the west side of section 20, township 42 north, range 2 west, it is again a series of rapids from 500 to 600 feet long, the fall being usually from 2 to 6 feet. From that point to the foot of Pelican Lake the fall is only 1.8 feet. At this locality a reservoir containing, perhaps, 500,000,000 cubic feet might be created; but as there were a sufficient number of other reservoirs ahead, of greater importance, to take up our time for the season, no survey was made.

From the foot of Pelican Lake to Bear Lake the river is again a series of rapids, between which are stretches of swift water varying from 1,000 to 4,000 feet in length. The river is from 50 to 125 feet wide, with banks from 5 to 20 feet high, while the ground rises back from the river 20 or 30 feet in one-half mile.

The drift from Chippewa Crossing to the existing dam below Bear Lake consists of a fine sandy loam somewhat impervious to water, and clay of a light reddish color, in which are invariably found numerous bowlders from 6 inches to 5 feet in diameter.

The swamps are usually peat, covered with a growth of tamarac, spruce, and cedar. The timber, taken in the order in which it predominates, consists of hemlock, white pine, tamarac, spruce, birch, balsam, maple, &c. At the east end of Bear Lake, and extending along on the north side of the river, is a windfall which occurred in 1867.

The elevation of low-water at Chippewa Crossing is 1,509.3 feet above the sea-level, the datum to which all elevations alluded to in this report are referred.

The elevation of low-water at Bear Lake and above the existing dam is 1,432.9 feet, making a fall of 76.4 feet from Chippewa Crossing to this point.

On June 19 we reached Bear Lake, which was the first reservoir surveyed. The elevation of low-water at the proposed dam-site is about 1,430 feet.

The reservoir has a watershed of 244.5 square miles, or 6,816,268,800 square feet.

The supply from one-third the rainfall, which for this region is assumed at 30 inches per annum, is 5,677,951,910 cubic feet. The superficial area of the reservoir is 117,631,476 square feet, equal to 4.2 square miles nearly, and its capacity is 1,113,148,856 cubic feet. Hence there will be a surplus of 4,564,803,054 cubic feet. Its capacity will give for 90 days 143.15 cubic feet per second. (See Table I.)

If one-fourth the rainfall is assumed as available, the supply will be 4,260,168,000 cubic feet, and the surplus 3,147,019,144 cubic feet, which will pass down to Little Chief Lake. (See Table II.)

The length of the dam will be 1015 feet, and its maximum height 19.5 feet above low-water. It requires a dike 200 feet long, with a maximum height of 8.5 feet. The ground at the dam-site consists of clay of a light reddish color, mixed with gravel and bowlders; there are, also, gravel and bowlders in the bed of the river; and from indications below the existing dam, the clay must extend to a considerable depth below the bed of the river. The only way, however, in which this fact can be determined is by excavations. I do not consider it possible to make borings at this locality.

The water in the reservoir will be confined principally to the lake itself, and to adjacent swamps, which are peat, and on which is a dense growth of tamarac, spruce, and white cedar, varying from 2 to 6 inches in diameter. Where hard ground is flooded, the ground, as already described, consists of sandy loam and clay. These two classes of soils are sometimes found in strata, sometimes in distinct masses, and sometimes running into another without any regularity, the clay as a rule, however, largely predominating. The pine within the limits of the reservoir, as well as for a considerable distance beyond, has been cut over once or twice and there is not much left that will be damaged by water.

At the proposed dam-site there is plenty of materials for the construction of a wooden dam.

DESCRIPTION OF THE EXISTING DAM BELOW BEAR LAKE.

This dam was constructed in August and September, 1877, by the Chippewa River Improvement Company, at a cost of $5,500. It is what is termed a flooding dam, and the object of it is, as well as of all others of its class, to store up water, and create what is termed a driving stage for logs by suddenly raising the gates. Its capacity is about 300,000,000 cubic feet, and requires about a month to fill during the low-water season. It has a water-way of 42 feet, and is built for a 10-foot head. There are four sliding gates, two of them 7 feet by 10 feet, and two 8 feet by 10 feet. There is also a sluice-way controlled by stop plank, 12 feet by 10 feet. The gates are raised by means of iron levers applied to cast-iron racks on the rear and lower sides of the gates. The planks are raised by means of a wooden windlass directly over the plank. The entire length of the dam is 574 feet. In looking at the dam from the south end there is, first, the left wing, 150 feet long; then a pier 36 feet long, 8 feet wide, and 12 feet high; then a sluice-way 7 feet wide and 10 feet deep; next a plank partition 1.5 feet wide; again a sluice-way 8 feet wide and 10 feet deep; next a pier with an ice-breaker 36 feet long, 7 feet wide, and 12 feet high; then a sluice-way 12 feet wide by 10 feet deep; again a pier 36 feet long, 7 feet wide, and 12 feet high; next a sluice-way 8 feet wide and 10 feet deep; then another partition 1.5 feet wide; next a sluice-way 7 feet wide and 10 feet deep; and again a pier 36 feet long, 7 feet wide, and 10 feet deep; lastly, the right wing, 350 feet long. These piers are said to rest on a foundation of clay, gravel, and brush, and are built of square timber and filled with rock. For the wings a cob work of long and heavy round logs is built up, the front of which is vertical, while the rear or upstream part has a slope of about 1¼ feet horizontal to 1 foot vertical to receive the covering, which is also of round logs from 12 to 14 inches in diameter. The foot of this covering simply rests on the ground, and is protected by a backing of clay, gravel, and brush. There is no covering in front of the wings, as the water is never allowed to flow over the dam.

Whenever the water rises to the top of the dam a gate is raised. Below the piers there is an apron 50 feet long; and in line with the main piers there are low piers on this apron about 3 feet high, and filled with rock. These are put in so that when all the gates are not open the water will not spread out on the apron. There is a great deal of leakage at this dam, and it would seem as if it would not last very long.

The survey of Bear Lake was finished on July 12.

Levels were next run to Little Chief Lake, which was the next reservoir surveyed. Levels were taken at the head and foot of the principal rapids. From Bear Lake to Little Chief Lake the river is very treacherous, and unsafe for canoes or bateaux, when it is above an ordinary stage, on account of rocks and sharp bends in the river. The worst of these are Cedar Rapids and Snaptail Rapids. Cedar Rapids are about 3

miles long, commencing about 2 miles below the proposed dam-site at Bear Lake, and ending at the southwest corner of section 10, township 40 north, range 4 west, the fall being about 54 feet. From Blaisdell's Lake (see general map) to the head of Snaptail Rapids the river has a gentle current. Snaptail Rapids are about 1¼ miles long, and end at Hunter's Lake, having a fall of 45 feet in that distance.

At Blaisdell's Lake a small reservoir might be created holding about 250,000,000 cubic feet of water, but having considered it too small it was not surveyed.

The country along the river from Bear Lake to Little Chief Lake is timbered with hemlock, white pine, tamarac, spruce, cedar, birch, balsam, &c. On the south side of Hunter's Lake there is an old windfall which occurred in 1872, stretching to the southwest, and northeast to Lake Superior.

The banks of the river from Bear Lake to the foot of Little Chief Lake vary from 4 to 50 feet high.

The ground along Hunter's Lake and Little Chief Lake, sometimes known as Barker's Lake, is from 35 to 60 feet high. The drift consists of sandy loam and a light reddish clay mixed with bowlders. It is what is termed a rocky soil. The swamps are peat and are covered with a dense growth of tamarac, spruce, and cedar.

Little Chief Lake reservoir has a watershed of 57.6 square miles, equal to 1,605,795,840 square feet. The superficial area is 46,781,532 square feet, equal to 1.6 square miles nearly. Its capacity is 771,332,009 cubic feet. The available supply from one-third the rainfall is 1,337,627,935 cubic feet. Hence the surplus from its own watershed is 566,295,926 cubic feet. Adding to this the surplus from the Bear Lake reservoir, for one-third the rainfall, we have a total surplus of 5,131,098,980 cubic feet. (See Table I.)

Assuming one-fourth the rainfall as available, there is a surplus of 232,290,391 cubic feet. Adding to this the surplus from the Bear Lake reservoir for one-fourth the rainfall and there is a total surplus of 3,379,309,535 cubic feet. (See Table II.) The reservoir will give a supply for 90 days of 99.19 cubic feet per second.

The proposed dam-site is located at the head of a series of rapids which extend down to the confluence of this branch with the West Fork.

The banks at the dam-site consist of sandy loam, clay, and bowlders. On the bed of the river and on the low ground there is a thick layer of bowlders, below which there is evidently the usual clay or perhaps rock.

The total length of the dam is 710 feet, and its maximum height above low-water 24 feet. The pine within the limits of this reservoir has been mostly cut, but there is an abundance left for all purposes of construction, and rock for pier filling is quite convenient.

The water in this reservoir will be confined chiefly to the lakes and adjacent swamps. The elevation of low-water at the dam-site is 1,323.4 feet; hence the total fall from Chippewa Crossing to that point is 185.9 feet.

The survey of Little Chief Lake reservoir was completed August 1. Levels were next run across from Little Chief Lake to the proposed dam-site on the West Fork of the Chippewa River. The elevation at that point is 1,285 feet. The fall from Little Chief Lake to the confluence of the East and West Forks is about 43 feet in a distance of 2¾ miles. The river between those points is a series of rapids, and the bed of the river is literally paved with bowlders. The banks are from 10 to 20 feet high, and the drift a reddish clay. Between the junction of the East and West Forks to the proposed dam-site at Pa-kwa-wang there is a swift current. There are several gravel bars, but no rapids.

We reached Pa-kwa-wang on August 2.

The Pa-kwa-wang reservoir has a watershed of 257.2 square miles, equal to 7,170,324,480 square feet. The supply from one-third the rainfall is 5,972,880,292 cubic feet. Its capacity is 7,692,997,229 cubic feet. The deficiency is received from the watershed to the Moose Lake reservoir, which is above this on the West Fork and has a large surplus. (See Table I.)

Its surface area is 580,578,192 square feet, equal to 20.8 square miles nearly. The surplus from one-third the rainfall received from the Moose Lake reservoir, and passing through this, is 1,234,725,814 cubic feet. (See Table I.) This reservoir will furnish for 90 days, 989.33 cubic feet per second.

From one-fourth the rainfall, after filling the Moose Lake reservoir, there will be a deficiency of 1,499,364,631 cubic feet. This deficiency may be received from the East Fork and still leave a surplus passing the dam at Little Chief Lake of 1,879,944,904 cubic feet. This will require a 25-foot dam at Little Chief Lake. The water will pass across from the southwest bay of the lake. (See A on general map.) The discharge, without making up the deficiency, will be, for 90 days, 796.5 cubic feet per second. (See Table II.)

The water in this reservoir will be confined principally to the river, swamps, and marshes. A few points of hard land will, however, be flooded, the soil of which consists of sand, sandy loam, and clay.

The timber on the hard ground on the east side of the West Fork, and on the west side of the river for a mile above the proposed dam-site, and again commencing about

a mile above the mouth of Little Chief River, consists of hemlock, white pine, tamarac, spruce, birch, balsam, &c. With this exception, the timber on the hard ground within the limits of this reservoir, and for several miles to the north and south of Little Chief River, consists of scattering Norway and white pine, usually damaged by fire. There are also numerous patches of poplar brush which has sprung up after fires. The ground to the north and south of Little Chief River is high and broken, rising sometimes 50 or 75 feet above the marshes bordering on the river.

The water in Little Chief River, in its tributaries and surrounding lakes, is clear spring-water, and is derived from the high ground surrounding, which is usually sand and sandy loam. In sections 14, 15, 21, 22, 23, township 40, range 7. there is a floating bog, which rises and falls with the river, which has scarcely any timber. (See general map.)

On the swamps there is a dense growth of spruce and tamarac, from 2 to 6 inches in diameter. The swamps are peat. The ground at the proposed dam-site, as already described, is clay and sandy loam. The bed of the river is coarse gravel, sand, and clay.

The West Fork of the Chippewa from the proposed dam-site to the mouth of Little Chief River is sluggish, there being only 1.5 feet fall in that distance. From there to the limit of flowage it consists of a series of rapids and still reaches, sometimes, three-fourths of a mile in length. Little Chief River and its tributaries in some places have a strong current, but usually the current is sluggish. Along these streams, as well as from the mouth of Little Chief River to the proposed dam-site, there are extensive rice-fields and meadows.

This reservoir lies mostly within the reserve for the Courtes-Oreilles band of Chippewa Indians. These Indians have selected lands within the limits of the reserve for farms and have been supplied by the government with farming implements. I have been informed that adults, both male and female, are entitled to 80 acres of land, and that those who have selected homesteads and made the necessary improvements are expecting to receive their patents this year. Their farms so far extend along the West Fork from the proposed dam-site to the mouth of Little Chief River, and again on the west and south sides of Chief Lake.

The length of the proposed dam is 900 feet, and maximum height above low-water 25.5 feet.

I have been informed that it is the intention of the Mississippi River Logging Company to construct a 16-foot dam this winter about 1,000 feet above the proposed dam-site here.

There are two small existing dams within the limits of this reservoir; one is located at the mouth of the outlet to Pokegama Lake and the other on Little Chief River at the northeast corner of section 26, township 40 north, range 7 west. The one at Pokegama Lake has a sluice-way 8 feet wide and 8 feet deep controlled by a sliding gate. Each wing is about 50 feet long with the covering sloping. Its construction is similar to that at Bear Lake. The dam on Little Chief River is 142 feet long and there are three sluice-ways, each 8 feet wide and 6 feet deep, controlled by sliding gates. The right wing is 37 feet long and the left 77 feet.

Instead of piers at the sluices there are partitions formed by planking rectangular frames resting on the floor of the sluices. The covering of the wings slope up stream and rest on cob-work of round logs, as at Bear Lake. The toe of the dam is first protected by driving sheet piles at the foot of the covering and in front of the sluices, and as an additional security there is a backing of clay and sandy loam.

There is a difference of 1 foot between the water above and below the dam. This dam creates a driving stage for logs out of the valley of Little Chief River and down the West Fork as far as the mouth of the East Fork. It cost $500 and was built in May.

The survey of this reservoir was completed September 6.

Levels were now continued up the West Fork to Moose Lake, where the next reservoir was surveyed. We reached that point on September 9.

The elevation of low-water below the existing dam there is 1,358.8 feet, and above the dam 1,361.9 feet. The proposed dam-site is 100 feet above the existing dam, and low-water is assumed at 1,358.8 feet.

The West Fork of the Chippewa, from the mouth of Little Chief River to Moose Lake, is a series of rapids, between which are stretches of sluggish water. The banks are generally from 10 to 30 feet high.

The timber along the river is mostly white pine and hemlock. Lumbering has been carried on along this portion of the river for a great many years, and close to the river there is not much pine of a good quality left. The soil is usually clay.

The area of the watershed of the Moose Lake reservoir is 214.3 square miles, and the supply from one-third the rainfall, which has been assumed at 30 inches, is 4,976,626,153 cubic feet, and its capacity is 2,021,783,402 cubic feet. Hence, after supplying the deficiency of water from the watershed of the Pa-kwa-wang reservoir for that dam, there is still a surplus of 1,234,725,814 cubic feet to pass down river. (See

Table I.) Its supply from one-fourth the rainfall is 3,733,963,200 cubic feet, and the surplus of 1,712,179,798 cubic feet goes into the Pa-kwa-wang reservoir and is there stored. (See Table II.) The surface area of the reservoir is 137,844,396 cubic feet, or 4.9 square miles nearly. The reservoir will give a supply of 260 cubic feet per second for a period of 90 days. The water in the reservoir will be confined chiefly to Moose Lake and adjoining swamps. It also extends up the West Fork to Partridge Crop Lake, but does not flood it any. The river from the proposed dam-site to Partridge Crop Lake consists of short and steep rapids and gravel-bars, their length being from 200 to 600 feet, having a fall from 2 to 6 feet. Between these rapids there are still reaches where the river is from 200 to 400 feet wide and the bottom soft. Beyond Partridge Crop Lake and to the source the river is from 20 to 50 feet wide, the river being sluggish. Occasionally there is a gravel-bar where there is a fall of about 2 feet, but there are no rapids. The river above the proposed dam-site is confined between banks which are from 20 to 30 feet high and the timber is mostly white pine and hemlock, the pine predominating.

Partridge Crop Lake is the farthest point up stream where pine has been cut. At the inlet to Moose Lake there is an extensive windfall, both on the hard ground and in the swamps which have been burned over. The timber around Moose Lake consists of hemlock, white pine, birch, tamarac, cedar, spruce, and balsam. The ground around Moose Lake is from 50 to 100 feet above the lake, considerably broken with short ravines making down to the lake. The ground consists of clay, gravel, and sandy loam. At the dam site the bed of the river and the low ground is a mass of bowlders from 6 inches to 3 feet in diameter. The existing dam is said to rest on a ledge of rock, but there is no outcropping of rock visible anywhere in the vicinity. The total length of the proposed dam is 1,235 feet, and maximum height above low-water 25.7 feet. The total length of dike is 160 feet, and maximum height 1.5 feet.

For the construction of a wooden dam there is plenty of pine timber convenient; also rock for pier-filling. No borings can be made at the dam-site on account of bowlders or rock in place.

DESCRIPTION OF EXISTING DAM AT MOOSE LAKE.

This is a flooding dam and is located at the head of a stretch of rapids and about 100 feet below the proposed dam-site. The dam is 347 feet long, and the head 7 feet. There are two sluice-ways, one 8 feet wide and 7 feet deep, controlled by a sliding gate, and one 16 feet wide, controlled by stop-logs. There are no piers, but the ends of the wings are faced with solid walls of 12 by 12 inch timber, and between the sluices there is a partition formed by planking a rectangular frame secured to the floor of the sluices and at the top to cross-pieces connecting the walls at the wings. In this partition and in the walls are slots for the gate and stop-logs. The wings are formed by placing round timbers, on a slope of 1¼ feet horizontal to 1 foot vertical, and allowing them to rest on a cob-work of heavy round logs.

The toe of the covering, as well as in front of the sluices, is protected by a backing of gravel and clay.

This dam is out of repair both at the sluices and at the south wing. At the south wing there is a break of 50 feet.

The reservoir from this dam has a capacity of about 430,000,000 cubic feet, and affords a driving stage for logs for about 12 days, as far at least as the mouth of the East Fork. It is owned by a Mr. Goodrich and was built in 1877 at a cost of $1,500.

There is another dam on the West Fork about a mile below Partridge Crop Lake. The south wing is 52 feet long and the north 59 feet long. It has but one sluice-way, 12 feet wide and 8 feet deep, and controlled by stop-logs. At the ends of the wings there are solid walls of timber, hewn on three sides, in which is a slot for stop-logs. The covering has a slope of about 1 to 1 and rests on a cob-work of round logs. The rear of the dam is protected by a backing of clay and gravel.

A small reservoir might be created at Crop and Lost Lakes, but the water-shed being only 33 square miles it was considered too small to survey.

The survey of Moose Lake reservoir was completed on September 30.

We next moved camp to Lake Courtes-Oreilles by way of Little Chief River and Chief Lake.

Levels were now run from Chief Lake to Lake Courtes-Oreilles, where we arrived on October 5. The elevation of Courtes-Oreilles is 1,287.2 feet; that of Grindstone, 1,287.6 feet; Fish Lake, 1,298.3 feet; Island Lake, 1,292 feet; and of Sand Lake, 1,301.1 feet. For the elevation of the other smaller lakes see general map. The elevation of low-water at the dam-site is 1,287.2 feet.

The Courtes-Oreilles reservoir has a watershed of 114 square miles, equal to 3,178,137,600 square feet. For one-third the rainfall its supply is 2,647,388,621 cubic feet, and the entire amount may be stored in itself. The superficial area of the reservoir for its own water will be 448,582,620 square feet, equal to 16.1 square miles, nearly.

The length of dam will be 260 feet, and height above low-water 6.5 feet. There will

be no dike, but a tamarac swamp, which seems to have been an old channel, will require, for a length of 100 feet, sheet piling 6 feet in length. For 90 days it will deliver 350.45 cubic feet per second. (See Table I.) The water within the limits of the reservoir will be confined wholly to lakes and small swamps. For one-fourth the rainfall the supply will be 1,986,336,000 cubic feet, which can be stored with a 5-foot dam above low-water.

The superficial area of the reservoir will be 435,756,814 square feet, equal to 15.6 square miles, nearly. The length of the dam will be 260 feet, as before, and sheet piling for a distance of 100 feet, and 5 feet long. Under this condition the reservoir will supply for 90 days 255,44 cubic feet per second. (See Table II.)

Now, instead of allowing any surplus water to pass Little Chief Lake, by constructing a 25-foot dam at that reservoir, the water may be passed over into the Pa-kwa-waug reservoir (see black dotted line marked A, on general map), and from there, together with the surplus from the West Fork, through a canal into Lake Courtes-Oreilles. This excavation amounts to 264,700 cubic yards of earth, and would probably cost about $52,940. (See profile attached and black dotted line marked B, on general map.) Now, supposing one-third the rainfall is available, this will give us in Courtes-Oreilles reservoir 9,013,213,415 cubic feet, which, for 90 days, will give 1,159.16 cubic feet per second. This will require a 20-foot dam above low-water. Its length will be 415 feet. It will also require a dike 2,850 feet long, and a maximum height of 13.5 feet.

The superficial area of the reservoir will be 496,781,760 square feet, equal to 17.8 square miles, nearly. (See Table III.)

Now, suppose that one-fourth the rainfall is available, we have for Courtes-Oreilles reservoir 3,366,280,904 cubic feet. This will require a dam 9.4 feet in height above low-water. Its length will be 297 feet. The length of dike will be 148 feet, with a maximum height of 3 feet.

The superficial area of the reservoir will be 449,000,000 square feet, equal to 16.1 square miles, nearly. Its supply for 90 days will be 497.21 cubic feet per second. (See Table IV.)

On the east, south, and west sides of Lake Courtes-Oreilles the hard ground is timbered with scattering Norway pine, jack-pine, scrub-oak, and poplar brush. On the swamps there is a heavy growth of tamarac from 4 to 8 inches in diameter. On the north and west sides of Grindstone Lake the timber is white pine, Norway pine, maple, birch, and tamarac. On the northeast and north sides of Fish Lake, and on the north and west sides of Sand Lake, the timber is scattering Norway pine and poplar brush. On the south side of Fish and Sand lakes the timber consists of poplar, maple, birch, tamarac, balsam, &c. The ground on the east, south, and west sides of Lake Courtes-Oreilles consists of sand, sandy loam, clay and gravel; also, on the north side of Fish and Sand lakes. Around Grindstone and Island lakes, and on the southwest side of Fish Lake, and south side of Sand Lake, the ground is clay and sandy loam. The ground in the vicinity of this reservoir varies from 20 to 70 feet in height above the water. The ground at the dam-site is clay, gravel, and sandy loam. The bed of the outlet of the dam-site consists of clay, gravel, and sand. The lakes usually have either a clay or gravel beach.

For pier-filling plenty of rock can be found along the lake shore. In looking at the general map it will be seen that there are but few streams emptying into it. Owing to the clearness of the water, the lakes are evidently largely supplied by spring-water. It seems apparent, however, from the small discharge in the river, that the rain absorbed in the ground, particularly on the western side of the reservoir, does not find its way into this reservoir, but seeks an outlet to the west, in which direction the country is falling. One-fourth the rainfall ought to be considered here, when one-third may in the other cases be used. The most of this reservoir lies within the reserve for the Courtes-Oreilles band of Chippewa Indians. As at Pa-kwa-waug the Indians have selected homesteads and are farming on a small scale.

There will be very little land damaged, either by a 6.5-foot dam or by a 20-foot dam, as there is no wild rice within the limits of the reservoir, and very litttle meadow land. The green line on the general map and the red line beyond where it joins the green is the flowage-line for a 20-foot dam, and the red line alone for either a 5 or a 6.5 foot dam.

The survey of the Courtes-Oreilles reservoir was completed on October 25.

We next proceeded by boat down the Courtes-Oreilles River and main Chippewa as far as Big Bend. As a matter of economy we left our boats at Big Bend, and traveled by stage to Chippewa Falls, and from there to Paint Creek, where the next and last reservoir was surveyed. We arrived there on October 29.

Courtes-Oreilles River is from 50 to 60 feet wide. The first 3 miles of it is sluggish, but from there to the mouth it is a series of rapids and still reaches. The worst of these rapids is known as Courtes-Oreilles Falls. The river at this point passes through a granite formation. The falls are situated within 3 miles of the mouth of the river. Courtes-Oreilles River is not navigable for bateaux at extreme low-water on account of rocks and gravel-bars.

The Chippewa River, from the mouth of the Courtes-Oreilles River to Big Bend, has a swift current the entire distance, and no rapids of any consequence.

Paint Creek Reservoir has a superficial area of 58,806,566 square feet, equal to 2.1 square miles. It has a watershed of 3,493.1 square miles, equal to 109,927,319,040 square feet. The supply from one-third the rainfall is 91,569,456,760 cubic feet. The capacity of the reservoir is 505,336,720 cubic feet. Hence the surplus is 91,064,120,040 cubic feet. It will furnish a supply of 64.99 cubic feet per second for 90 days.

The following tables—I, II, III, IV—show the areas of watersheds and reservoirs supply from *one-third* or *one-fourth* the rainfall; capacities and supply per second for 90 days; also, cost of dams. Table V shows discharge of streams.

Assuming *one-third* the rainfall as available, and allowing the surplus from the East and West Forks of the Chippewa River, and the surplus from Butternut Lake, Rest Lake, Bear Creek, Round Lake, Squaw Lake, and Park Lake to pass down river, there will be a surplus passing the Paint Creek Dam—which is the lowest dam on the Chippewa waters—of 102,148,325,526 cubic feet. The quantity of water stored in the reservoirs will give a supply of 3,245.79 cubic feet per second for 90 days. (See Table I.) Again, supposing that the surplus from the East and West Forks is allowed to pass through a canal into Lake Courtes-Oreilles, there will be a surplus passing Paint Creek of 95,782,500,732 cubic feet. The quantity of water stored will give a supply of 4,064.50 cubic feet per second for 90 days. (See Table III.) Assuming that one-fourth the rainfall is available, and allowing the surplus from the East Fork of the Chippewa to pass down river, there will pass at Paint Creek a surplus of 74,101,054,095 cubic feet. The supply under this condition will be, for 90 days, 2,784.42 cubic feet per second. (See Table II.)

Lastly. Assuming that the surplus from the East and West Forks is directed into Pa-kwa-wang and Courtes-Oreilles, there will be a surplus passing Paint Creek of 70,721,744,560 cubic feet. The water stored will give a supply for 90 days of 3,219.[illegible] cubic feet per second. (See Table IV.)

In the vicinity of Paint Creek Reservoir the hard ground is usually of a sandy nature. The swamps seem to be muck. The timber consists of scattering white and Norway pine, tamarac, and scrub-oak.

There is no land within the limits of the reservoir that is cultivated, for the reason that it is not worth cultivating. There is an existing dam across the Chippewa River at the proposed dam-site, and certain lands along the river have already been condemned.

The proposed dam may be built over the one now existing. Its length will be [illegible] feet, and height 22 feet above low-water.

TABLE OF ELEVATIONS OF IMPORTANT POINTS WITHIN THE LIMITS OF THE SURVEY ABOVE THE SEA-LEVEL, AT LOW-WATER.

	Feet.
Low-water at Chippewa Crossing	1,50[illegible]
Bear Lake	1,432.[illegible]
Proposed dam-site at Bear Lake	1,430.[illegible]
Head of Cedar Rapids	1,42[illegible]
Foot of Cedar Rapids	1,337.[illegible]
Head of Snaptail Rapids	1,36[illegible]
Foot of Snaptail Rapids	1,32[illegible]
Hunter's Lake	1,32[illegible]
Little Chief Lake	1,323.4
Proposed dam-site at Little Chief Lake	1,323.4
Proposed dam-site at Pa-kwa-wang	1,25[illegible]
Chief Lake	1,295.7
Proposed dam-site at Moose Lake	1,33[illegible]
Moose Lake	1,361.9
Partridge Crop Lake	1,384.[illegible]
Summer Lake	1,39[illegible].1
Crop Lake	1,384.[illegible]
Lost Lake	1,335.[illegible]
Lake Courts-Oreilles	1,2[illegible]7.[illegible]
Island Lake	1,292
Little Courts-Oreilles Lake	1,28[illegible].4
Fish Lake	1,2[illegible]
Sand Lake	1,301.1
Little Sand Lake	1,303.[illegible]
Flat Lake	1,320.3
Proposed dam-site at Lake Courts-Oreilles	1,287.[illegible]
Pokegama Lake	1,290.5
Crane Lake	1,300.7

The following is a list of existing dams, operated by private parties, on the Chippewa River and its tributaries, *within the limits* of our survey:

1. *Goodrich's Dam*, on the West Fork, situated in the southwest quarter of the southwest quarter of section 32, township 42 north, range 5 west:

Height of stop-plank above foundation	feet..	8
Width of sluice-way	do...	12
Length of dam	do...	123
Dead-head	do...	3

2. *Goodrich's Dam*, on West Fork of Chippewa River, near mouth of Moose Lake, situated in the northeast quarter of the southeast quarter of section 14, township 41 north, range 6 west:

Height of sluice-ways above flooring	feet..	7
Total width of sluice-ways	do...	24
Length of dam	do...	347
Dead-head	do...	2.1
Capacity	cubic feet..	430,000,000

3. *Dam on outlet to Pokegama Lake*, situated in the northwest quarter of the north west quarter of section 32, township 40 north, range 6 west:

Height of sluice-way above flooring	feet..	8
Width of sluice-way	do...	8
Length of dam	do...	108

4. *Haywood's Dam*, on Little Chief River, located in the northeast quarter of the northeast quarter of section 26, township 40, range 7 west:

Height of sluice-way above flooring	feet..	6
Width of sluice-way	do...	24
Length of dam	do...	142
Dead-head	do...	1

5. *Chippewa River Improvement Company's Dam at Bear Lake*, on East Fork, situated in the northwest quarter of southeast quarter of section 26, township 41 north, range 4 west:

Height of sluice-ways above flooring	feet..	10
Width of sluice-ways	do ...	42
Length of dam	do ...	564
Capacity	cubic feet..	300,000,000

6. *Little Falls Dam*, situated in southeast quarter of the northwest quarter of section 28, township 32, range 6:

Height of sluice-ways above flooring	feet..	21
Total width of sluice-ways	do...	267
Length of dam	do...	625
Dead-head	do...	5
Capacity	cubic feet..	133,333,333

7. *Paint Creek Dam*, situated in the southeast quarter of the northwest quarter of section 3, township 28 north, range 8 west, on the Chippewa River:

This is a rolling dam, with a log-way 100 feet wide at the center, and near the right bank a lumber slide 23 feet wide.

Crest of dam above low-water	feet..	10½
Total length of dam	do...	526

DESCRIPTION OF DAM ACROSS THE CHIPPEWA RIVER AT PAINT CREEK.

This dam is situated in the southeast quarter of the northwest quarter of section 3, township 28 north, range 8 west, at the proposed dam-site for the Paint Creek Reservoir. In looking at the dam from the right bank of the river there is first a shore-pier of crib-work 17 by 37 feet, and filled with rock. The top of this pier is about 30 feet above low-water, and was built to that height with a view to raising the present dam 12 feet. Then comes a crib-work of timber, the top of which is 18.5 feet above low-water, 100 feet long and filled with stone; next in order is the right pier of the lumber slide, 10 feet wide and 206 feet long, then the lumber slide 23 feet wide. This has an adjustable apron at the upper end, the crest of which is 8 feet above low-water when it is down. At the lower end is a floating apron. Next in order is the left pier, with an ice-breaker. The upper portion of it, for a distance of 80 feet, is 16 feet wide, and the remainder, 126 feet, is 10 feet wide. The upper ends of these piers are about

19 feet above low-water, and lower by steps as we approach the end of the slide. Then comes the rolling dam, 360 feet long, in the center of which is a roll-way for logs, about 100 feet wide. The covering in the rear of the dam has a slope of about 1½ feet horizontal to 1 foot vertical. In front of the dam the covering has a slope of about 1 to 1, with the exception of the roll-way, where the slope is about 4 feet horizontal to 1 foot vertical. This covering rests on crib-work of timber and filled with rock. The toe of the dam is protected by a backing of sand and gravel. The bottom of the river at this place is a granite formation, the planes of cleavage of which are at an angle of about 15° from the vertical. The granite in this vicinity seems to be of a good quality, and is used as a building stone.

In looking at the general map, it will be seen from elevations of different points within the limit of our survey that the country, besides falling to the southwest, also falls to the west along the summit. The elevation of low-water at Chippewa Crossing is 1,509 feet above the sea-level, but the headwaters of Bad River are about 1,600 feet above the sea, and there are points on the Penokee Iron Range which are over 1,700 feet. It is a common opinion among persons who have spent considerable time at various points in Northern Wisconsin that the rainfall is more than in the southern part of the State, and I am satisfied that when the mean annual rainfall is ascertained for this region it will not be far from 36 inches.

Northern Wisconsin is still a vast wilderness, and from the progress that emigration has made into that portion of the State since it was opened by the Wisconsin Central Railroad, it promises to remain so for twenty or thirty years to come. This is partially owing to the labor required in clearing up the land, but more especially to the fact that the clay soil which predominates in that region is generally impervious to water. Besides this, rocks are so common in the soil that the lands are not desirable for farming purposes. Even in swamps we almost invariably find bowlders and gravel at the bottom. Hence it is difficult to see where the existence of reservoirs in this region will interfere either directly or indirectly with agricultural interests.

In regard to damages to water-power for mill-sites, it is not probable that lumber will ever be manufactured in this region, for the reason that the market for the lumber of the Chippewa Valley is in the Mississippi Valley, and until we reach the vicinity of Chippewa Falls it would be impossible to run lumber without going to an unwarrantable expense. In view of the above considerations the reservoirs will not be detrimental to the manufacture of lumber. The only cause of complaint that could arise, providing that the lumbering interests were made subservient to the interests of commerce in the Mississippi Valley, is, perhaps, a delay of one or two months in getting the drives to their destination at Chippewa Falls, Eau Claire, and points below. But when we consider that during winters when the fall of snow is very small the lumbering interests are embarrassed during the entire season following, as was the case on the Chippewa in 1878, a delay of a month or two is only a guarantee, in the end, of successful operations during each season.

Very respectfully, your obedient servant,

ARCHIBALD JOHNSON,
Assistant Engineer.

Maj. CHARLES J. ALLEN,
Captain, Corps of Engineers, U. S. A.

APPENDIX c.

WISCONSIN RIVER.

REPORT OF MR. JAMES D. RAYNOLDS, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, January 5, 1880.

MAJOR: I have the honor to submit the following report of examination of the sources of the Wisconsin and part of the Chippewa rivers, made under your direction from June 21 to October 18, 1879.

The region which I was instructed to examine, with a view to ascertaining its capabilities for storage reservoirs, included the Wisconsin River above Pelican, the Tomahawk above Squirrel, the Doré Flambeau above Fifield, and the North Fork of the Flambeau at and above its junction with the Manitouish.

This I have divided for convenience into five principal watersheds, as shown on the general maps, and designated as follows:

I. *Pelican.*—Covering the Wisconsin watershed between Pelican River and Otter Rapids.

II. *Eagle.*—Including all the Wisconsin River above Otter Rapids.

III. *Tomahawk.*—Including all of Tomahawk River above section 7, township 39 north, range 6 east.

IV. *Bear Creek.*—Embracing the Manitouish as far as Rest Lake, and Bear Creek, with the lakes where it takes its rise.

V. *Round Lake.*—Including all the Doré Flambeau above Round Lake.

[Below Round Lake I was unable to find any available holding-ground, the stream being a continual succession of rapids. I made, also, some examination of Pelican River, since the high banks near its mouth seemed to promise considerable holding-ground. The stream was found, however, to have such rapid fall that even a 30-foot dam would flow but an insignificant area.]

I.—PELICAN WATERSHED. AREA, 361 SQUARE MILES.

Here we found two available dam-sites, one of which may be designated as "Pelican" proper, the other "Sugar Camp." Both have already been utilized by lumbermen.

At Pelican is a dam, built in 1878, of Norway pine, of the common cob-work pattern, concerning which I gathered the following data:

Height above floor of sluice-way	10.5 feet.
Length on crest	425 feet.
Cost	$4,700

Probable duration variously estimated at three to eight years. From present appearances I should judge the lower limit to be nearest the truth, as Norway timber is soon destroyed by exposure to the weather and to alternate wetting and drying.

The present reservoir was never full but once—in May, 1879: Four weeks were required to fill it. When the gates are opened the escaping water reaches Wausau in from 50 to 52 hours. At this rate seven days would be required after opening the gates at Pelican for the water to reach the Mississippi at Prairie du Chien.

From a careful survey of the possible flowage area above Pelican Dam the following results were obtained:

	Cubic feet.
Capacity of reservoir with present dam (10.5 feet rise above "dead-head" or 13.5 feet rise above mean low-water)	880,000,000
Capacity with 20 feet rise	2,298,632,320
Capacity with 28 feet rise	5,153,180,527

To raise the water 28 feet would require a dam 800 feet long on crest, and a dike at head of "Lake No. 1" (as shown on detail map) having a length of 3,625 feet, and a maximum height of 15 feet.

The probable cost of this work, if executed at the present time, I place at $62,929.

The dam on Sugar Camp Creek was built some three years ago. It is 230 feet long and 5 feet high. Although of even cheaper construction than Pelican Dam, it is in a very fair state of preservation. It has, however, not been in use since the first season, logging operations having been suspended since then.

By substituting a dam on this site 12.5 feet high and building in addition a low dike 260 feet long, a reservoir would be formed having an estimated capacity of 1,356,284,160 cubic feet. The cost of this work I place at $8,162.

Careful gaugings of the river just below Pelican Dam, June 23 and 24, showed a discharge of 620 cubic feet per second. In the opinion of those most familiar with the river, it was at this time at about a mean stage. Assuming this to be true, a discharge of 620 cubic feet per second, for the entire year, would give 19,552,320,000 cubic feet.

The total drainage area above Pelican is 857 square miles, which, counting on .83 foot available rainfall, would give a yearly supply of 19,830,184,704 cubic feet. The drainage area of Pelican watershed alone (below Otter Rapids) is—

Tributary to Pelican reservoir	301 square miles.
Tributary to Sugar Camp reservoir	60 square miles.

Assuming as available one-third of an annual rainfall of 30 inches over the whole watershed, except the portions flowed, and assuming, further, that, on account of evaporation, only one-sixth of that rainfall can be retained over the flooded area, we have—

	Capacity.	Drainage area.	Net supply from rainfall.	Surplus.
	Cubic feet.	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*
Pelican, 20 feet rise	2,298,632,320	301	6,836,596,800	4,537,964,480
Sugar Camp, 12.5 feet rise	1,356,284,160	60	1,335,840,000	....
OR,				
Pelican, 28 feet rise	5,153,180,527	301	6,836,596,800	1,683,416,273
Sugar Camp, 12.5 feet rise	1,356,284,160	60	1,335,840,000	....

From these two reservoirs could be delivered, for a period of 90 days, 834.5 cubic feet per second.

The total land area which would be flooded is—

	State swamp lands.	Entered.	United States.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Pelican	2,222	833	3,999	7,[illegible]
Sugar Camp	1,448	326	433	2,[illegible]
Total	3,670	1,159	4,432	9,[illegible]

What good pine grew here has long ago been cut, and the land is, in my opinion, entirely worthless for agriculture, except some narrow strips of hay meadow and bottom lands, now timbered with elm, white maple, &c., perhaps 2,000 acres altogether. None of it is at present under cultivation.

II.—EAGLE WATERSHED. AREA, 496 SQUARE MILES.

Here were found three good dam-sites, all of which have been utilized by lumbermen. One at the head of Otter Rapids, one on Eagle River between Catfish and Cranberry lakes, and one on Eagle River (here called "Fish-Trap Creek") above Cranberry Lake. The two latter dams were abandoned many years ago, and have fallen into complete decay. The dam at the head of Otter Rapids was built in the summer of 1878. It was nearly filled once (in December, 1878), raising the water about 5 feet above floor of sluice-way, or 7 feet above low-water, when the east wing "blew out," being poorly anchored in the treacherous, gravelly bank, and since then has been abandoned. From the survey of this location it was found that the water might safely be raised to a height of 22 feet. This would require, in addition to the dam, a low dike 700 feet long. By this means would be flooded the entire Eagle Lake system, giving a holding capacity of 7,389,727,488 cubic feet.

A cheaper plan than the above (though giving less holding capacity) would be to build the dam at Otter Rapids but 19 feet high, dispensing with the dike, and another dam on Fish-Trap Creek 8 feet high, thus forming two reservoirs, having a combined capacity of 5,851,676,160 cubic feet; or, instead of an 8-foot dam on Fish-Trap, one [illegible] feet high might be built between Catfish and Cranberry lakes, which, in conjunction with the 19-foot dam at Otter Rapids, would give a capacity of 6,163,000,[illegible] cubic feet.

The probable supply was arrived at by two methods:

1st. Careful gaugings of the Wisconsin, just above Otter Rapids, showed a discharge of 296 cubic feet per second, at a time when, from the best information obtainable, estimated the discharge to be about 80 per cent. of the yearly mean. Assuming this to be true, the entire annual discharge would be 11,668,320,000 cubic feet.

2d. The area of Eagle watershed is 496 square miles, which, counting on .33 for available rainfall, would give a yearly supply of 11,476,979,712 cubic feet.

The supply indicated by either of these methods is largely in excess of the maximum holding capacity of reservoir. Some additional capacity might be obtained by damming the outlets of Lake Vieux Desert and Twin Lakes. The amount stored would, however, be small, owing to the limited watershed tributary to these lakes, [illegible] 360,096,000 cubic feet for Vieux Desert and 621,456,000 cubic feet for Twin Lakes.

Vieux Desert I was unable to examine, but I learned from those familiar with the country that a good dam-site exists near its outlet.

I made a tour of exploration to Twin Lakes, and estimated that, to store all the water obtainable, would require a dam 6 feet high and 1,500 feet long.

Assuming, as before, that over the whole watershed, except the portions flowed, one-third of an annual rainfall of 30 inches can be counted on; and that on account of evaporation only one-sixth of that rainfall can be retained over the flowed area, we have—

	Cubic feet.
$\frac{10}{12}$ foot × 12,594,345,984 =	10,495,2[illegible]
$\frac{5}{12}$ foot × 1,233,340,416 =	513,[illegible]
Total net supply Eagle watershed	11,009,1[illegible]

Tabulating the above, we have as the best result obtainable for the Eagle watershed—

	Capacity of reservoir.	Drainage area.	Net supply from rainfall.	Surplus.
	Cubic feet.	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*
Otter, 22 feet rise	7, 389, 727, 488	447	10, 027, 628, 160	2, 637, 990, 672
Vieux Desert	400, 000, 000	19	360, 096, 000	
Twin Lakes	650, 000, 000	30	621, 056, 000	

From these three reservoirs could be delivered for a period of 90 days 1,076.54 cubic feet per second.

The probable cost, estimating at present prices, I place at $38,113 for dam and dike at Otter Rapids; $10,000 for dam at Twin Lakes, and $5,000 for dam at Lake Vieux Desert. Total, $53,113.

The area covered by these reservoirs is in greater part already covered by water, since the principal holding-ground consists of lakes with quickly-rising banks.

The total land area which would be flooded is—

	State swamp lands.	Entered.	Military wagon-road grant.	Ownership not ascertained, approximate.	United States.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Otter Rapids	4, 692	597	371		1, 893	7, 553
Twin Lakes				750		750
Vieux Desert				750		750
Total	4 692	597	371	1, 500	1, 893	9, 053

It is of very small value, having been already stripped of its pine lumber, and offering not the smallest inducement to agricultural enterprise. Perhaps 500 acres consists of valuable hay meadows on the Wisconsin proper.

III.—TOMAHAWK WATERSHED.

This basin is comparatively small, comprising but 101.5 square miles. From this, by the same process as before, I deduct as the net annual supply 2,201,580,480 cubic feet, which can all be retained by a dam 12 feet high, for which an excellent site was found in section 7, township 39 north, range 6 east, where the high banks are less than 200 feet apart. Retaining all the water above this point reduces the area tributary to the Squirrel Creek reservoir (reconnoitered by Mr. Charles Wanzer in 1878) to 56 square miles, yielding an annual supply for storage of 1,239,427,200 cubic feet. To retain even this limited amount will probably require a dam 17 feet high, since further examination than was possible last winter has developed the fact that Squirrel Lake and adjacent swamps are above any attainable flowage plane, thus reducing the available holding-ground to less than half the area at which it was first estimated.

A gauging of the Tomahawk River, just above the selected dam site, at a time when the water was apparently at a trifle below mean stage, showed a discharge of 64 cubic feet per second, which, if uniform for an entire year, would give as the available supply 2,018,304,000 cubic feet.

The land flooded by proposed reservoirs on the Tomahawk River would be as follows:

	State swamp lands.	Entered.	Railroad.	Indian reservation.	United States.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Upper Tomahawk	548	215		120	1, 087	1, 970
Squirrel	2, 370	105	80		495	3, 050
Rice Lake	587	403			1, 508	2, 498
Total	3, 505	723	80	120	3, 090	7, 518

There is a small Indian settlement between Lakes Kawaquesagon and Tomahawk, where a few acres are devoted to raising corn and potatoes. A narrow margin of these plantings would be flooded by the proposed dam, which would also drown out some quite extensive fields of wild rice, covering several hundred acres. With these exceptions, I know of no injury that would be done to any private interests.

I place the probable cost of proposed works on the Tomahawk at the following figures:

Upper Tomahawk dam	$4,729 00
Squirrel dam and dike	17,115 00
Rice Lake dam	24,930 00
Total	46,774 00

IV.—BEAR CREEK WATERSHED, 154.5 SQUARE MILES.

This is an extensive but shallow basin, affording larger holding-ground, though in no place could high banks be found coming near enough together to render damming easy except just below Lake Flambeau, where a dam 265 feet long and but 4 feet high would hold all the water tributary to the lakes above. This amount is small, however, about 1,000,000,000 cubic feet.

The site offering the best results is immediately below the junction of the Manitouish with Bear Creek. Here good banks are found, though at a formidable distance apart—2,500 feet. A dam could be built here 15 feet high, which, in conjunction with 2,000 feet of dike, would back the water over the lakes at head of Bear Creek and flood extensive meadows on Bear Creek and the Manitouish, forming a reservoir having an estimated capacity of 5,406,567,152 cubic feet. This reservoir would have, when full, a surface area of 1,156,953,600 square feet. Computing one-sixth of an annual rainfall of 30 inches over this area, and one-third of that rainfall over the rest of the watershed, we have, as the net annual supply, 3,107,280,000 cubic feet. The capacity of the reservoir is thus seen to be in excess of the supply by 2,299,287,1[illegible] cubic feet, which will go far towards retaining the surplus (3,057,100,264 cubic feet coming over from Rest Lake reservoir above.

Rest Lake reservoir was surveyed by Mr. J. H. Dager, in 1878, and described in his report.

Tabulating results, we have for Bear Creek and Rest Lake watersheds:

	Capacity of reservoir.	Drainage area.	Net supply from rainfall.	Surplus.
	Cubic feet.	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*
Bear Creek	5,406,567,152	154.5	3,107,280,000	757,81[illegible]
Rest Lake	1,840,000,000	211.643	4,897,100,264	

Amount deliverable for a period of 90 days, per second, 931.91 cubic feet.

If constructed at the present time I estimate the cost of the above works as follows:

For Bear Creek dam	$38,[illegible]
For Bear Creek dike	9,[illegible]
For Rest Lake dam	7,[illegible]
For Rest Lake dike	[illegible]
Total	55,1[illegible]

The area to be flooded consists, aside from the lake systems, mainly of extensive meadows covered with excellent grass. There would also be drowned out some large fields of wild rice, from which the Indians on the Flambeau reservation derive at present a main item of subsistence. These Indians expressed great discontent at the possibility of any part of their domain being flooded, even showing a strong disposition to interfere with the progress of the survey.

V.—ROUND LAKE WATERSHED.

At the outlet of Round Lake a dam of fair construction already exists. It was built in 1876, and partially rebuilt since, at a total cost of $3,000, and is probably still good for five or six years' service. It is 170 feet long and raises the water 6 feet, with storage capacity for 884,860,000 cubic feet. The dam might safely be raised to a height of 10 feet, which, with a dike 250 feet long, would form a reservoir holding 1,303,036,41[illegible] cubic feet.

A good dam-site is found also below the outlet of Squaw Lake, in section 28, township 40 north, range 4 east. Here a dam 9 feet high would give a capacity of 731,808,000 cubic feet. Assuming the rainfall at 30 inches, and computing one-sixth of this on the area overflowed and one-third over the rest of the watershed, we have, tabulating the above:

	Capacity of reservoir.	Drainage area.	Net supply from rainfall.	Surplus.
	Cubic feet.	*Sq. miles.*	*Cubic feet.*	*Cubic feet.*
Round Lake	1,303,036,416	63	1,382,304,000	79,267,584
Squaw Lake	731,808,000	39	864,230,400	132,422,400
Total	2,034,844,416	102	2,246,534,400	211,689,984

This would give for a period of 90 days a discharge, per second, of 261.68 cubic feet. With prices as at the present time, I estimate the cost of construction as follows:

For Round Lake dam	$7,360
For Round Lake dike	3,190
For Squaw Lake dam	4,000
Total	14,550

Of the land area which would be flooded, a small part is well adapted for farming. The only portion at present under cultivation is a farm near the outlet of Pike Lake, of which a few acres would be submerged; the larger part is well above flowage. Some wild-rice fields would be drowned out; with these exceptions, the land to be overflowed is nearly valueless.

METHODS OF SURVEY.

On the Pelican reservoir, transmit and compass lines were run, meandering both lakes and swamps, and cross-sections taken at frequent intervals whereby the several contours up to 20 feet were accurately determined, and for the southern portion (where most of the holding-ground is) up to 28 feet. Progress was, however, necessarily slow, the swamps being thickly grown with tamarac and cedar, requiring a large force of axmen to cut out lines. Six weeks were consumed on this work, and it became evident that to make an equally detailed survey of the entire ground I was directed to examine would require more than double the time at my disposal. From this point, therefore, a system was adopted involving less accuracy of detail, but which, it is believed, has given results sufficiently close for present purposes and generally correct to within 10 or 15 per cent.

All the lakes encountered were found already meandered by the United States land surveys, and from these, and from cross-sections taken at sufficiently frequent intervals to determine the slope of their banks, their capacity as holding reservoirs was determined, the elevation of their natural surfaces being of course in all instances obtained by careful lines of levels from dam-site.

The swamps lying within reservoir limits were found almost without exception to have a tolerably uniform slope, determinable by random lines of levels projected into them where necessary. By this means, and by reference to the land maps, and verification of their indicated swamp areas by exploration, the different flowage lines were drawn in.

In the case of Pelican reservoir the results given are very accurate for a 20-foot dam, but less so for a 28-foot dam. For the latter my estimate of capacity is probably somewhat too low.

Throughout the survey a carefully-tested continuous line of levels was run, and finally connected with the bench at the mouth of Manitouish, to which levels had previously been run from the Wisconsin Central Railroad, giving its true height above the sea. My levels were then corrected back (in note-books) so as to refer all elevations to sea-level.

Bench marks were established at prominent points over the entire work, clearly marked for future reference.

Concerning foundation for dams I can give little satisfactory information. No rock in place was anywhere encountered. Beneath a thin deposit of mud or surface-soil was found in all cases a drift formation, consisting of sand and gravel thickly interspersed with bowlders of all sizes up to 10 feet diameter, rendering it impossible to force a sounding-rod down to ascertain what lay beneath. From the frequency of side-hill swamps perhaps it may be inferred that an impervious stratum of clay exists at no great depth.

Recapitulation of estimated cost of dams and dikes proposed on the Wisconsin River.

Designation of reservoir.	Cost of dam.	Cost of dike.	Total.
Pelican	$35,250 00	$27,679 00	$62,929 00
Sugar Camp	7,350 00	812 00	8,162 00
Otter Rapids	35,365 00	2,748 00	38,113 00
Twin Lakes	10,000 00	....	10,000 00
Vieux Desert	5,000 00	....	5,000 00
Tomahawk	4,729 00	....	4,729 00
Squirrel	14,790 00	2,325 00	17,115 00
Rice	24,930 00	....	24,930 00
Total	137,414 00	33,564 00	170,978 00

Table showing the actual acreage, as nearly as it could be reckoned, of lands which would be overflowed by proposed dams on the Wisconsin River.

Designation of reservoir.	State swamp-lands.	Entered lands.	Military wagon-road grant.	Indian reservation.	Ownership not ascertained; approximate.	United States public lands.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Pelican	2,222	833	......	......	......	3,999	[illegible]
Sugar Camp	1,448	326	......	......	......	433	[illegible]
Otter Rapids	4,692	597	371	......	......	1,893	[illegible]
Twin Lakes	......	......	......	......	750	......	[illegible]
Vieux Desert	......	......	......	......	750	......	[illegible]
Tomahawk	548	215	......	120	......	1,087	[illegible]
Squirrel	2,370	185	......	......	......	495	[illegible]
Rice	587	403	......	......	......	1,508	[illegible]
Total	11,867	2,559	371	120	1,500	9,415	[illegible]

Very respectfully, your obedient servant,

JAMES D. RAYNOLDS,
Assistant Engineer.

Maj. CHARLES J. ALLEN,
Captain, Corps of Engineers, U. S. A.

APPENDIX d.

TABLE I.—SAINT CROIX RIVER.

Table showing drainage area, supply by one-third rainfall, capacity of reservoirs, and quantity furnished per day and second for 90 days; also, surplus from watershed above Taylor's Falls not held by proposed dams. Rainfall, 25 inches.

River.	Reservoir.	Drainage area to each reservoir.		Supply by one-third annual rainfall, 0.70.	Capacity of reservoir.	Surplus.
		Sq. miles.	*Square feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
	Mud Lake	27½	766, 656, 000	536, 659, 200	396, 377, 420	140, 281, 780
Yellow	Rice Lake	134½	3, 749, 644, 800	2, 624, 751, 360	2, 474, 944, 500	149, 806, 860
	Yellow Lake	159½	4, 446, 604, 800	3, 112, 623, 360	3, 402, 712, 000	
Namakagon	Veazies	436	12, 154, 982, 400	8, 508, 487, 680	1, 379, 393, 850	7, 129, 093, 830
	Mouth of Totogatic	212	5, 910, 220, 800	4, 137, 154, 560	3, 082, 033, 820	1, 055, 120, 740
	Upper Totogatic	71. 15	1, 983, 722, 400	1, 388, 605, 680	1, 388, 605, 680	
Totogatic	Gilmore Lake	258. 85	7, 216, 149, 600	5, 051, 304, 720	2, 881, 095, 000	2, 170, 209, 720
	Mouth of Totogatic	59	1, 644, 825, 600	1, 151, 377, 920	1, 541, 016, 900	
Saint Croix	Eau Claire Lakes	71	1, 979, 366, 400	1, 385, 556, 480	961, 045, 400	424, 511, 080
	Upper Saint Croix	219	6, 105, 369, 600	4, 273, 758, 720	4, 698, 269, 800	
Clam	Clam Lake	283½	7, 903, 526, 400	5, 532, 468, 480	4, 670, 786, 500	861, 681, 980
Snake	Ground House	116	3, 233, 894, 400	2, 263, 726, 080	1, 045, 440, 000	1, 218, 286, 080
	Chengwatana	866	24, 142, 694, 400	16, 899, 886, 080	3, 703, 238, 000	13, 196, 643, 080
Saint Croix	Lower Saint Croix	1, 030	28, 714, 752, 000	20, 100, 326, 400	2, 709, 500, 000	17, 390, 826, 400
Add watershed of Kettle River		1, 033	28, 798, 387, 200	20, 158, 871, 040		20, 158, 871, 040
Watershed of Snake River delow dam, and Saint Croix, from mouth of Snake to dam		35	975, 744, 000	683, 020, 800		683, 020, 800
Saint Croix, above mouth of Snake—total		5, 012	139, 726, 540, 800	97, 808, 578, 560	34, 334, 458, 870	64, 578, 358, 390
Saint Croix, from mouth of Snake to Taylor's Falls		1, 000	27, 878, 400, 000	19, 514, 880, 000		
Saint Croix River, above Taylor's Falls—total		6, 012	167, 604, 940, 800	117, 323, 458, 560		

APPENDIX *d*—Continued.

River.	Reservoir.	Excess of capacity over supply.	Surplus held by dams below.	Total surplus not held by dams.	From reservoirs, full, can be furnished for 90 days— Per day.	Per second.	Height of dam above low-water.	Cost of dams, not including damage to property.
		Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Feet.*	
	Mud Lake		140, 281, 780		4, 404, 194	51	6	$1, 200 00
Yellow	Rice Lake		149, 806, 860		27, 499, 382	318	25½	33, 266 70
	Yellow Lake	290, 088, 640			37, 807, 911	438	20	15, 403 92
Namakagon	Veazie's				15, 326, 598	177	31½	32, 762 75
	Mouth of Totogatic			8, 184, 214, 570	34, 244, 820	396	41	43, 610 45
	Upper Totogatic				15, 428, 932	178	12½	7, 482 38
Totogatic	Gilmore Lake		389, 638, 980		32, 012, 166	370	30	21, 876 65
	Mouth of Totogatic	389, 638, 980		1, 780, 570, 740	17, 122, 410	198		
Saint Croix	Eau Claire lakes		424, 511, 080		10, 678, 292	124	12½	9, 635 79
	Upper Saint Croix	424, 511, 080			52, 202, 998	604	24½	94, 319 55
Clam	Clam Lake			861, 681, 980	51, 897, 628	602	26	27, 217 33
Snake	Ground House				11, 616, 000	134	20	8, 500 00
	Chengwatana			14, 414, 934, 160	41, 147, 088	476	13	30, 000 00
Saint Croix	Lower Saint Croix			17, 390, 826, 400	30, 105, 555	349	23½	60, 444 76
Add watershed of Kettle River								
Watershed of Snake River below dam, and Saint Croix, from mouth of Snake to dam				20, 841, 891, 840				
Saint Croix, above mouth of Snake—total		1, 104, 238, 700	1, 104, 238, 700	63, 474, 119, 690	381, 493, 985	4, 415		385, 720 28
Saint Croix, from mouth of Snake to Taylor's Falls				19, 514, 880, 000				
Saint Croix River, above Taylor's Falls—total				82, 988, 999, 690				

APPENDIX e.

TABLE II.—SAINT CROIX RIVER.

Table showing drainage area, supply by one-fourth rainfall, capacity of reservoirs and quantity furnished per day and second for ninety days; also, surplus from watershed above Taylor's Falls not held by proposed dams. Rainfall, 25 inches.

River.	Reservoir.	Drainage area to each reservoir.		Supply by one-quarter annual rainfall, 0.52.	Capacity of reservoir.	Surplus.	Excess of capacity over supply.
		Sq. miles.	*Sq. feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
	Mud Lake						
Yellow	Rice Lakes	162	4,516,300,800	2,348,476,416	2,474,944,500		126,468,084
	Yellow Lake	159½	4,446,604,800	2,312,234,496	3,402,712,000		1,090,477,504
Namakagon	Veazie's	436	12,154,982,400	6,320,590,848	1,379,393,850	4,941,196,998	
	Mouth of Totogatic	212	5,910,220,800	3,073,314,816	3,082,033,820		8,719,004
	Upper Totogatic	71.15	1,983,722,400	1,031,535,648	1,388,605,680		357,070,032
Totogatic	Gilmore Lake	258.85	7,216,149,600	3,752,397,792	2,881,095,000	871,302,792	
	Mouth of Totogatic	59	1,644,825,600	855,309,312	1,541,016,900		685,707,588
Saint Croix	Eau Claire lakes						
	Upper Saint Croix	290	8,084,736,000	4,204,062,720	4,698,269,800		494,207,080
Clam	Clam Lake	283½	7,903,526,400	4,109,833,728	4,670,786,500		560,952,772
Saint Croix	Lower Saint Croix	1,030	28,714,752,000	14,931,671,040	2,709,500,000	12,222,171,040	
Snake	Ground House	116	3,233,894,400	1,681,625,088	1,045,440,000	636,185,088	
	Chengwatana	866	24,142,694,400	12,554,201,088	3,703,238,000	8,850,963,088	
Add watershed of Kettle River		1,033	28,798,387,200	14,975,161,344			
Watershed of Snake River, below dam, and Saint Croix, from mouth of Snake to dam		35	975,744,000	507,386,880			
Saint Croix, above mouth of Snake—total		5,012	139,726,540,800	72,657,801,216			
Saint Croix, from mouth of Snake to Taylor's Falls		1,000	27,878,400,000	14,496,768,000			
Saint Croix River, above Taylor's Falls—total		6,012	167,604,940,800	87,154,569,216			

APPENDIX *d*—Continued.

River.	Reservoir.	Excess of capacity over supply.	Surplus held by dams below.	Total surplus not held by dams.	From reservoirs, full, can be furnished for 90 days— Per day.	Per second.	Height of dam above low-water.	Cost of dams, not including damage to property.
		Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Feet.*	
	Mud Lake		140, 281, 780		4, 404, 194	51	6	$1, 200 00
Yellow	Rice Lake		149, 806, 860		27, 499, 382	318	25½	33, 266 70
	Yellow Lake	290, 088, 640			37, 807, 911	438	20	15, 403 92
Namakagon	Veazie's				15, 326, 598	177	31½	32, 762 75
	Mouth of Totogatic			8, 184, 214, 570	34, 244, 820	396	41	43, 610 45
	Upper Totogatic				15, 428, 932	178	12½	7, 482 38
Totogatic	Gilmore Lake		389, 638, 980		32, 012, 166	370	30	21, 876 65
	Mouth of Totogatic	389, 638, 980		1, 780, 570, 740	17, 122, 410	198		
Saint Croix	Eau Claire lakes		424, 511, 080		10, 678, 292	124	12½	9, 635 79
	Upper Saint Croix	424, 511, 080			52, 202, 998	604	24½	94, 319 55
Clam	Clam Lake			861, 681, 980	51, 897, 628	602	26	27, 217 33
Snake	Ground House				11, 616, 000	134	20	8, 500 00
	Chengwatana			14, 414, 934, 160	41, 147, 088	476	13	30, 000 00
Saint Croix	Lower Saint Croix			17, 390, 826, 400	30, 105, 555	349	23½	60, 444 76
Add watershed of Kettle River								
Watershed of Snake River below dam, and Saint Croix, from mouth of Snake to dam				20, 841, 891, 840				
Saint Croix, above mouth of Snake—total		1, 104, 238, 700	1, 104, 238, 700	63, 474, 119, 690	381, 493, 985	4, 415		385, 720 28
Saint Croix, from mouth of Snake to Taylor's Falls				19, 514, 880, 000				
Saint Croix River, above Taylor's Falls—total				82, 988, 999, 690				

APPENDIX *f*.

TABLE III.—SAINT CROIX RIVER.

Discharge in cubic feet per second of the Saint Croix River and tributaries.

Date.	Station.	Height above low-water.	Area of cross-section.	Slope.	Mean velocity.	Discharge in cubic feet per second.
1879.						
Oct. 14	Saint Croix River, at head of Kettle River Rapids	0. 600	1, 595. 8	0. 000356	1. 351	2, 158. 7
	......do	0. 600	1, 595. 8	0. 000356	1. 313	2, 095. 7
	......do	0. 600	1, 595. 8	0. 000356	1. 322	2, 114. 1
	......do	0. 600	1, 595. 8	0. 000356	1. 220	1, 951. 2
July 11	Yellow River, at Rice Lake dam site	0. 600	462. 1	0. 000356	0. 457	211. 1
	......do	0. 600	462. 1	0. 000356	0. 424	196. 2
July 14	Namakagon River, at Veazie's dam site	1. 400	288. 1	0. 000152	1. 349	388. 8
	......do	1. 400	288. 1	0. 000152	1. 377	396. 9
Aug. 29	Namakagon, at lower dam site	0. 800	494. 0	0. 000350	1. 575	778. 4
	......do	0. 800	494. 0	0. 000350	1. 626	803. 5
Aug. 14	Totogatic River, at upper dam site	0. 300	130. 2	....	0. 246	32. 1
	......do	0. 300	130. 2	....	0. 222	28. 9
	......do	0. 300	130. 2	....	0. 202	26. 3
	......do	0. 300	130. 2	....	0. 222	29. 0
Aug. 29	Totogatic River, at the mouth	1. 000	199. 7	0. 000015	1. 324	264. 4
	......do	1. 000	199. 7	0. 000015	1. 339	267. 4
	......do	1. 000	199. 7	0. 000015	1. 462	278. 6
	......do	1. 000	199. 7	0. 000015	1. 356	270. 9
	......do	1. 000	199. 7	0. 000015	1. 363	272. 2
Aug. 8	Eau Claire, at dam site	0. 500	73. 0	0. 000031	0. 991	72. 4
Sept. 19	Clam River, at dam site	(*)	(*)	(*)	(*)	103. 6
Sept. 26	Snake River, at Brunswick	0. 300	160. 7	0. 000213	0. 352	56. 6
	......do	0. 300	160. 7	0. 000213	0. 341	54. 9
Oct. 13	Rettle River, one-half mile above mouth	0. 420	514. 0	0. 00058	1. 103	564. 7
	......do	0. 420	514. 0	0. 00058	1. 107	569. 0
	......do	0. 420	514. 0	0. 00058	1. 033	531. 1

* Low-water measured weir.

APPENDIX *g*.

TABLE IV.—SAINT CROIX RIVER.

Elevations and slopes on Totogatic and Eau Claire rivers.

Point of observation.	Approximate elevation above the sea.	True elevation above the sea.	Fall from last point.	Total fall.	Distance from last point.	Total distance.	Slope per mile from last point.	Slope per mile on total distance.
Totogatic River.					*Miles.*	*Miles.*	*Feet.*	*Feet.*
Limit of upper reservoir		1, 255	......	....	......	......	......	......
Indian Crossing		1, 246	9	9	2	2	4. 5	4. 5
Upper dam site		1, 241	5	14	8	10	0. 6	1. 4
Blackburn's Crossing		1, 168	73	87	4	14	18. 2	6. 2
Mouth of Eagle-nest Creek		1, 003	165	252	17	31	9. 7	8. 1
Mouth of Cranberry Creek		984	19	271	8	39	2. 4	6. 9
Gilmore Lake dam site		975	9	280	4	43	2. 2	6. 5
Mouth of Chicorg Creek		958	17	297	6	49	2. 9	6. 0
Mouth of Totogatic River		918	40	337	10	59	4. 0	5. 7
Eau Claire River.								
Second Eau Claire Lake		1, 122	......	......	......	......	......	......
First Eau Claire Lake dam site		1, 119	3	3	3	3	1. 0	1. 0
Six miles below dam site		1, 073	46	49	7	10	6. 6	4. 9
At Antoine Gordon's		1, 012	61	110	7	17	8. 7	6. 5
At mouth of Eau Claire	1, 008	....	4	114	½	17½	8. 0	6. 5

Elevation and slopes on Yellow and Namakagon Rivers.

Point of observation.	Approximate elevation above the sea.	True elevation above the sea.	Fall from last point.	Total fall.	Distance from last point.	Total distance.	Slope per mile from last point.	Slope per mile on total distance.
Yellow River.							*Feet.*	*Feet.*
Mud Lake dam site		1,085						
Rice Lake dam site		969	116	116	20	20	5.8	[illegible]
Yellow Lake dam site		928	41	157	28	48	1.5	[illegible]
Mouth of Yellow River	888		40	197	7	55	5.7	[illegible]
Namakagon River.								
Little Puckwawance		1,218						
Mouth of Chippenacia Creek		1,115	103	103	16	16	6.4	[illegible]
Mouth of Spring Brook		1,068	47	150	6	22	7.9	[illegible]
Mouth of Jordan River		1,058	10	160	1½	23½	6.6	[illegible]
Veazie's dam site		1,039	19	179	8	31½	2.4	[illegible]
Mouth of Stuntz Brook		952	87	266	14½	46	6.0	[illegible]
Mouth of McKenzie Brook		944	8	274	3	49	2.6	[illegible]
Mouth of Totogatic River		918	26	300	10	59	2.6	[illegible]
Lower dam site		917	1	301	1	60	1.0	[illegible]
Mouth of Namakagon River	908		9	310	4	64	2.2	[illegible]

Elevations and slopes on Snake, Kettle, and Clam rivers.

Snake River.								
Mouth of Knife River		964						
Mouth of Ann River		943	21	21	5	5	4.2	[illegible]
Mouth of Ground House		940	3	24	4	9	0.75	[illegible]
At Chengwatana		929	11	35	23	32	0.5	[illegible]
Mouth of Snake River	790		139	174	12	44	11.6	[illegible]
Kettle River.								
Northern Pacific Railroad crossing		1,299						
Willow River, on St. Paul and Duluth Railroad		1,023	276	276	36	36	7.7	
Kettle River Station		1,016	7	283	5	41	1.4	[illegible]
Mouth of Kettle River	816		200	483	33	74	6.6	[illegible]
Clam River.								
Limit of proposed reservoir		967						
At dam-site		947	20	20	10	10	2.0	[illegible]
At Saint Croix Road Crossing		881	66	86	13	23	5.0	[illegible]
Mouth of Clam River	866		15	101	6	29	2.5	[illegible]

Elevation of water-surface, at ordinary stage, of various points on the Saint Croix River with slope per mile.

Upper Saint Croix Lake		1,010						
Mouth of Moose River		1,001	9	9	21	21	0.4	[illegible]
Mouth of Namakagon River	908		93	102	17	38	5.5	[illegible]
Mouth of Yellow River	888		20	122	12	50	1.7	[illegible]
Mouth of Clam River	866		22	144	12	62	1.8	[illegible]
Head of Kettle River Rapids	850		16	160	9	71	1.8	[illegible]
Mouth of Kettle River	816		34	194	2½	73½	13.6	[illegible]
Foot of Kettle River Rapids	801		15	219	1½	75	10.0	[illegible]
Mouth of Snake River	790		11	230	3	78	3.8	[illegible]
Rush City Ferry		773	17	247	12	90	1.4	[illegible]
Taylor's Falls		679	94	341	30	120	3.1	[illegible]
Stillwater		662	17	358	29	149	0.6	[illegible]

APPENDIX h.

Table V.—Saint Croix River.

Location and cost of dams for reservoirs on the Saint Croix River and tributaries.

Name and location of dam.	Class of structure on which cost of dam was estimated.	Length of dam, not including dike.	Height of dam above low-water.	Cost of dam, not including cost of dike.	Length of dike, earth embankment.	Height of dike.	Cost of dike.	Cost of dams, including cost of dikes.
		Feet.	*Feet.*		*Feet.*	*Feet.*		
Mud Lake, section 27, township 37 north, range 12 west	Earth and cob work!	120	6	$1,200 00				$1,200 00
Rice Lake, section 16, township 39 north, range 14 west	Crib-work filled with stone or gravel	500	25½	29,066 70	1,500	13	$4,200 00	33,266 70
Yellow Lake, section 24, township 40 north, range 17 west	Timber and earth	230	20	15,403 92				15,403 92
Veazie's, section 36, township 40 north, range 12 west	Crib-work filled with stone or gravel	380	31½	29,605 25	700	6	3,157 50	32,762 75
Mouth of Totogatic, section 33, township 42 north, range 14 west	do	600	41	43,610 45				43,610 45
Upper Totogatic, section 12, township 42 north, range 10 west	Timber and earth	360	12½	7,482 38				7,482 38
Gilmore Lake, section 13, township 42 north, range 13 west	Crib-work with gravel filling, timber piers, and embankment.	380	30	21,876 65				21,876 65
Eau Claire Lake, section 25, township 44 north, range 10 west	Timber and earth	220	12½	9,635 79				9,635 79
Saint Croix Lake, section 35, township 44 north, range 13 west	Earth and stone	3,000	24½	94,319 55				94,319 55
Clam Lake, section 26, township 39 north, range 16 west	Timber and earth	550	26	27,217 33				27,217 33
Head of Kettle River Rapids, section 2, township 39 north, range 19 west.	Timber, earth, and stone	2,450	23½	60,444 76				60,444 76
Ground House, section 7, township 38 north, range 24 west	Earth and stone	700	20	8,500 00				8,500 00
Chengwatana, section 26, township 39 north, range 21 west	do	600	13	30,000 00				30,000 00
Total		10,190		378,362 78	2,200		7,357 50	385,720 28

APPENDIX *i*.

TABLE VI.—SAINT CROIX RIVER.

List of existing sluicing-dams owned by private parties or corporations in operation on the Saint Croix watershed.

Location of dam.	To whom charter is granted.	When built.	Head.	Width of gate-way.	Holding capacity.	Number of days' driving.	Cost.	Remarks.
			Feet.	*Feet.*	*Cubic feet.*			
Namakagon Lake	Namakagon and Totogatic Dam Company.	1869	9	30	1,500,000,000	20	....	Generally fills to 6-foot head in eleven months. Filled to 9-foot head once in nine years.
Totogatic dam, section 12, township 42, range 10	do	1860	9	30	1,250,000,000	....	$1,180	Kept in good repair; might be utilized for holding its capacity. Is the only one of consequence on this stream.
Saint Croix dam, section 7, township 44, range 11	do	1871	10	100	....	2½	....	Gives two or three days' driving, with gate-discharge of 450 square feet. This discharge raises the water 1 foot on Kettle River Rapids, 50 miles below.
Clam Lake	do	1877	8	36	700,000,000	....	1,230	Dam in good condition. The head cannot be raised, except at great expense.
Mud Lake dam on Yellow River	do	......	7½	30	475,000,000	7 to 10	800	Can be utilized for holding its capacity with slight repairs.
Hector dam, section 10, township 38, range 13	do	......	7½	30	....	2	800	Very small holding grounds.
Rice Lake dam	do	1878	10	30	700,000,000	....	2,200	Rebuilt in 1878. The head might be raised to 15 feet.
Yellow Lake	do	1869	10	57	1,400,000,000	....	1,800	In poor condition; needs rebuilding.
First Eau Claire Lake	do	1867	8	48	500,000,000	....	1,500	Worthless.
Third Eau Claire Lake	Walker, Judd & Veazie	1872	8	48	500,000,000	....	....	In good condition.
Hanscom, section 2, township 40, range 10	....	......	......	......	....	1	....	Very small holding grounds.
Puckwawance, section 1, township 41, range 9	....	......	......	......	....	....	....	Holding grounds small.
	To whom licensed.							
Knife River, section 15, township 40, range 24	Danforth Bros. & Bean	......	8	40	....	6	1,500	162 square feet gate-discharge; raises Snake River 1.2 feet.
Ann River, section 30, township 40, range 24	do	......	6	40	....	6	1,000	Holding grounds small.
Ann River, section 24, township 39, range 24	do	......	8	24	....	6	1,000	Do.
Ground House, section 7, township 38, range 24	....	......	11	26	300,000,000	6	2,000	Raises Snake River 6 inches.
Chengwatana	Anna Munch	1877	9½	116	1,680,819,200	....	6,300	Very small holding ground.
Upper Snake River, section 32, township 42, range 23	....	......	10	32	....	1	....	
Mud Creek, section 1, township 39, range 23	....	......	6	16	1,500,000,000	....	500	

APPENDIX *j*.

TABLE VII.—SAINT CROIX RIVER.

Miles of telegraph line required to connect the Saint Croix system of reservoirs.

	Miles.
Pine City, on Saint Paul and Duluth Railroad, to dam on Ground House	24
Pine City, on Saint Paul and Duluth Railroad, to dam at Chengwatana	2
Chengwatana to dam on Saint Croix, at head of Kettle River Rapids	14
Head of Kettle River Rapids to dam on Yellow Lake	14
Yellow Lake to dam on Namakagon, below the mouth of Totogatic River	18
Mouth of Totogatic to dam on Saint Croix, below Lake Saint Croix	14
Branch (offset) to dam on Totogatic, below Gilmore Lake	5
Lake Saint Croix to dam at outlet of Eau Claire Lake	19
Eau Claire Lake to dam on Upper Totogatic	9
Mouth of Totogatic to dam on Namakagon, at Veazie's	21
Yellow Lake to dam on Clam River, below Clam Lake	10
Clam Lake to dam on Yellow River, below Rice Lakes	10
Total	160

Making Pine City, on the Saint Paul and Duluth Railroad, the headquarters office of the system, this point being 64 miles distant from Saint Paul.

APPENDIX *k*.

TABLE VIII.—SAINT CROIX RIVER.

List of lands and approximate areas which will be overflowed by proposed reservoirs on Saint Croix River and tributaries.

[Omitted.—See House Ex. Doc. No. 39, Forty-sixth Congress, second session, pp. 64–74.]

Summary of lands and approximate areas which will be flowed by proposed reservoirs on the Saint Croix River and tributaries.

Location.	Swamp lands.	School lands.	Entered lands.	Railroad lands.	United States lands.	At each reservoir, total lands.
IN STATE OF WISCONSIN.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Rice Lakes	623	400	123	1,829	949	3,924
Yellow Lake	841	....	578	....	4,573	5,992
Clam Lake	1,246	85	709	4,353	2,579	8,972
Head of Kettle River Rapids	5,645	....	2,352	160	219	8,376
Veazie's	120	....	183	2,633	3,031	5,967
Upper Saint Croix	9,894	....	180	2,964	1,761	14,799
Lower Namakagon	40	239	380	4,911	4,732	10,302
Eau Claire Lake	234	160	365	1,008	926	2,693
Upper Totogatic	2,216	....	280	3,051	360	5,907
Gilmore Lake	120	238	40	3,382	3,974	7,754
IN STATE OF MINNESOTA.						
Chengwatana	1,840	709	15,912	1,073	195	19,729
Ground House	1,440	640	5,357	160	80	7,677
Total	24,259	2,471	26,522	25,524	23,379	102,092

NOTE.—Approximately correct.

APPENDIX i.

Table VI.—Saint Croix River.

List of existing sluicing-dams owned by private parties or corporations in operation on the Saint Croix watershed.

Location of dam.	To whom charter is granted.	When built.	Head.	Width of gate-way.	Holding capacity.	Number of days' driving.	Cost.	Remarks.
			Feet.	*Feet.*	*Cubic feet.*			
Namakagon Lake	Namakagon and Totogatic Dam Company.	1869	9	30	1, 500, 000, 000	20	....	Generally fills to 6-foot head in eleven months. Filled to 9-foot head once in nine years.
Totogatic dam, section 12, township 42, range 10	do	1860	9	30	1, 250, 000, 000	....	$1, 180	Kept in good repair; might be utilized for holding its capacity. Is the only one of consequence on this stream.
Saint Croix dam, section 7, township 44, range 11	do	1871	10	100	....	2½	....	Gives two or three days' driving, with gate-discharge of 450 square feet. This discharge raises the water 1 foot on Kettle River Rapids, 50 miles below.
Clam Lake	do	1877	8	36	700, 000, 000	....	1, 230	Dam in good condition. The head cannot be raised, except at great expense.
Mud Lake dam on Yellow River	do	......	7½	30	475, 000, 000	7 to 10	800	Can be utilized for holding its capacity with slight repairs.
Hector dam, section 10, township 38, range 13	do	......	7½	30	....	2	800	Very small holding grounds.
Rice Lake dam	do	1878	10	30	700, 000, 000	....	2, 200	Rebuilt in 1878. The head might be raised to 15 feet.
Yellow Lake	do	1869	10	57	1, 400, 000, 000	....	1, 800	In poor condition; needs rebuilding.
First Eau Claire Lake	do	1867	8	48	500, 000, 000	....	1, 500	Worthless.
Third Eau Claire Lake	Walker, Judd & Veazie	1872	8	48	500, 000, 000	....	....	In good condition.
Hanscom, section 2, township 40, range 10	....	......	......	......	....	1	....	Very small holding grounds.
Puckwawance, section 1, township 41, range 9	....	......	......	......	....	....	....	Holding grounds small.
	To whom licensed.							
Knife River, section 15, township 40, range 24	Danforth Bros. & Bean	......	8	40	....	6	1,.500	162 square feet gate-discharge; raises Snake River 1.2 feet.
Ann River, section 30, township 40, range 24	do	......	6	40	....	6	1, 000	Holding grounds small.
Ann River, section 24, township 39, range 24	do	......	8	24	....	6	1, 000	Do.
Ground House, section 7, township 38, range 24	....	......	11	26	300, 000, 000	6	2, 000	Raises Snake River 6 inches.
Chengwatana	Anna Munch	1877	9½	116	1, 689, 819, 200	....	6, 300	
Upper Snake River, section 32, township 42, range 23	....	......	10	32	....	1	....	Very small holding ground.
Mud Creek, section 1, township 39, range 23	....	......	6	16	1, 500, 000, 000	....	500	

APPENDIX m.

TABLE II.—CHIPPEWA RIVER.

Stream on which proposed dam is located.	Name of reservoir.	Area of watershed to reservoir.		Supply from one-fourth of 30 inches rainfall.	Capacity of reservoir.	Surplus over capacity of reservoir.	Supply from reservoir for 90 days.	Length of dam.	Length of dike.	Maximum height of dam above low-water.	Maximum height of dike.	Cost of dam, including dike.
		Sq. miles.	Square feet.	Cubic feet.	Cubic feet.	Cubic feet.	C.ft.p.sec.	Lin. ft.	Lin. ft.	L. ft.	L. ft.	
East Fork Chippewa River..	Bear Lake	244. 50	6, 816, 268, 800	4, 260, 168, 000	1, 113, 148, 856	3, 147, 019, 144	143. 15	1, 015	200	19. 5	8. 5	$25, 925
Do	Little Chief Lake	57. 60	1, 605, 795, 840	1, 003, 622, 400	771, 332, 009	232, 290, 391	99. 19	710	....	24. 0	......	40, 702
West Fork Chippewa River.	Moose Lake	214. 30	5, 974, 341, 120	3, 733, 963, 200	2, 021, 783, 402	....	260. 00	1, 235	160	25. 7	1. 5	45, 090
Do	Pa-kwa-wang	257. 20	7, 170, 324, 480	4, 481, 452, 800	6, 193, 632, 598	....	796. 50	840	....	23. 0	......	55, 617
Courtes Oreilles............	Courtes Oreilles...	114. 00	3, 178, 137, 600	1, 986, 336, 000	1, 986, 336, 000	....	255. 44	260	P. 100	5. 0	P. 5. 0	1, 631
Chippewa River	Paint Creek	3, 493. 10	109, 927, 319, 040	68, 704, 574, 400	505, 336, 720	68, 199, 237, 680	64. 99	620	....	22. 0	......	60, 000
Total	....	4, 830. 70	134, 672, 186, 880	84, 170, 116, 800	12, 591, 569, 585	71, 578, 547, 215	1, 619. 27	4, 680	460	......	......	228, 965
Butternut Creek............	Butternut Lake...	40. 00	1, 115, 136, 000	696, 960, 000	*585, 446, 400	111, 513, 600	*75. 26	336	....	*10. 0	......	5, 216
Manitouish	Rest Lake	†211. 64	†5, 900, 120, 800	†3, 687, 615, 360	†1, 840, 000, 000	Excess of capacity of reservoirs over supply, 1,427,137,008.	†236. 62	250	75	†15. 0	2. 5	†7, 665
North Fork Flambeau	Bear Creek	†54. 50	†4, 307, 212, 800	†2, 450, 976, 000	†5, 406, 567, 152		†552. 81	†2, 560	†2, 000	†‖15. 0	†‖10. 5	†47, 500
Doré Flambeau	Round Lake	†63. 00	†1, 756, 339, 200	†1, 057, 056, 000	†1, 303, 036, 416		†135. 93	†170	†250	†15. 0	†‖10. 0	†10, 550
Do	Squaw Lake	†39. 00	†1, 087, 257, 600	†658, 627, 200	†631, 808, 000		†84. 70	†250	....	†9. 0	......	†4, 000
Turtle River...............	Park Lake........	*174. 00	*4, 850, 841, 600	3, 031, 776, 000	*620, 782, 720	2, 410, 993, 280	79. 83	297	....	*15. 0	......	9, 941
Grand total	....	5, 512. 84	153, 689, 094, 880	95, 753, 127, 360	23, 079, 210, 273	74, 101, 054, 095	2, 784. 42	8, 483	2, 785	......	......	313, 837

NOTE.—The quantities marked thus (*) are taken from Assistant J. D. Skinner's report of 1878, and the quantities marked thus (†) are taken from Assistant J. D. Raynolds's report of 1879. (See reports alluded to.) The quantities are introduced here to show the surplus water passing at Paint Creek Dam, the lowest dam in the system, as well as the total supply per second for 90 days, and total cost of dams for the Chippewa River system of reservoirs. The quantities in the columns for dimensions of dikes, marked P. denote here sheet-piling.

APPENDIX n.

TABLE III.—CHIPPEWA RIVER.

Stream on which proposed dam is located.	Name of reservoir.	Area of watershed to reservoir.		Supply from one-third of 30 inches rainfall.	Capacity of reservoir.	Surplus over capacity of reservoir.	Supply from reservoir for 90 days.	Length of dam.	Length of dike.	Maximum height of dam above low-water.	Maximum height of dike.	Cost o dam, including dike.
		Sq. miles.	Square feet.	Cubic feet.	Cubic feet.	Cubic feet.	C ft. p. sec.	Lin. ft.	Lin. ft.	L. ft.	L. ft.	
East Fork Chippewa River	Bear Lake	244.50	6,816,268,800	5,677,951,910	1,113,148,856	Surplus from E.	143.15	1,015	200	19.5	8.5	$25,925
Do	Little Chief Lake	57.60	1,605,795,840	1,337,627,935	771,332,009	and W. Forks	99.19	725	....	25.0	......	45,183
West Fork Chippewa River	Moose Lake	214.30	5,974,341,120	4,976,626,153	2,021,783,402	turned into	260.00	1,235	160	25.7	1.5	45,090
Do	Pa-kwa-wang	257.20	7,170,324,480	5,972,880,292	7,692,997,229	Courtes Oreilles	989.33	900	....	25.5	......	66,449
Courtes Oreilles	Courtes Oreilles	114.00	3,178,137,600	2,647,388,621	9,013,213,415	through a canal.	1,159.16	415	2,850	20.0	13.5	36,752
Chippewa River	Paint Creek	3,943.10	109,927,319,040	91,569,456,760	505,336,720	91,064,120,040	64.99	620	....	22.0	......	60,000
Total		4,830.70	134,672,186,880	112,181,931,671	21,117,811,631	91,064,120,040	2,715.82	4,910	3,210	......	......	279,399
Butternut Creek	Butternut Lake	40.00	1,115,136,000	928,908,288	*585,446,400	343,461,888	*75.26	336	....	*10.0	......	5,216
Manitouish	Rest Lake	†211.64	†5,900,120,800	*4,897,100,264	†1,840,000,000	†757,813,112	†236.62	250	75	†15.0	2.5	†7,665
North Fork Flambeau	Bear Creek	†154.50	†4,307,212,800	†3,107,280,000	†5,406,567,152		†695.29	†2,500	†2,000	†15.0	†10.5	†47,500
Doré Flambeau	Round Lake	†63.00	†1,756,339,200	†1,382,304,000	†1,303,036,416	†79,267,584	†167.57	†170	†250	†10.0	†10.0	†10,550
Do	Squaw Lake	†39.00	†1,087,257,600	†864,230,400	†731,808,000	†132,421,400	†94.11	†250	....	†9.0	.....	†4,000
Turtle River	Park Lake	*174.00	*4,850,841,600	*4,026,198,428	*620,782,720	*3,405,415,708	79.83	297	....	*15.0	......	9,941
Grand total		5,512.84	153,689,094,880	127,387,953,051	31,605,452,319	95,782,500,732	4,064.50	8,713	5,535	......	......	364,271

NOTE.—The quantities marked thus (*) are taken from Assistant J. D. Skinner's report of 1878; and the quantities marked thus (†) are taken from Assistant J. D. Raynolds's report of 1879. (See reports alluded to.) The quantities are introduced here to show the surplus water passing at Paint Creek dam, the lowest dam in the system, as well as the total supply per second for 90 days, and total cost of dams for the Chippewa River system of reservoirs.

APPENDIX o.

TABLE IV.—CHIPPEWA RIVER.

Stream on which proposed dam is located.	Name of reservoir.	Area of watershed to reservoir.		Supply from one-fourth of 30 inches rainfall.	Capacity of reservoir.	Surplus over capacity of reservoir.	Supply from reservoir for 90 days.	Length of dam.	Length of dike.	Maximum height of dam above low-water.	Maximum height of dike.	Cost of dam, including dike.
		Sq. miles.	Square feet.	Cubic feet.	Cubic feet.	Cubic feet.	C.ft.p.sec.	Lin.ft.	Lin.ft.	L.ft.	L.ft.	
East Fork Chippewa River..	Bear Lake........	244.50	6,816,268,800	4,260,168,000	1,113,148,856	Surplus from E. Fork turned into Pa-kwa-wang and Courtes Oreilles.	143.15	1,015	200	19.5	8.5	$25,925
Do..................	Little Chief Lake.	57.60	1,605,795,840	1,003,622,400	771,332,009		99.19	725	....	25.0	......	45,183
West Fork Chippewa River..	Moose Lake.......	214.30	5,974,341,120	3,733,963,200	2,021,783,402		260.00	1,235	160	25.7	1.5	45,090
Do..................	Pa-kwa-wang.....	257.20	7,170,324,480	4,481,452,800	7,692,997,229		989.33	900	....	25.5	......	66,449
Courtes Oreilles............	Courtes Oreilles...	114.00	3,178,137,600	1,986,336,000	3,866,280,904		497.21	297	148	9.4	3.0	6,254
Chippewa River	Paint Creek.......	3,943.10	109,927,319,040	68,704,574,400	505,336,720	68,199,237,680	64.99	620	....	22.0	......	60,000
Total		4,830.70	134,672,186,880	84,170,116,800	15,970,879,120	68,199,237,680	2,053.87	4,792	508	......	......	248,901
Butternut Creek	Butternut Lake...	40.00	1,115,136,000	696,960,000	*585,446,400	111,513,600	*75.26	336	....	*10.0	......	5,216
Monatouish	Rest Lake	†211.64	†5,900,120,800	†3,687,615,360	†1,840,000,000	Excess of capacity of reservoirs over supply, 1,427,137,008, in ft.	†236.62	250	75	†15.0	2.5	†7,665
North Fork Flambeau	Bear Creek	†154.50	†4,307,212,800	†2,450,976,000	†5,406,567,152		†552.81	†2,500	†2,000	†15.0	†10.5	†47,500
Doré Flambeau	Round Lake	†63.00	†1,756,339,200	†1,057,056,000	†1,303,036,416		†135.93	†170	†250	†10.0	†10.0	†10,550
Do..................	Squaw Lake	†39.00	†1,087,257,600	†658,627,200	†731,808,000		†84.70	†250	....	†9.0	......	†4,000
Turtle River................	Park Lake........	*174.00	*4,850,841,600	3,031,776,000	*620,782,720	2,410,993,280	79.83	297	....	*15.0	......	9,941
Grand total	....	5,512.84	153,689,094,880	95,753,127,360	26,458,519,808	70,721,744,560	3,219.02	8,595	2,833	......	......	333,773

NOTE.—The quantities marked thus (*) are taken from Assistant J. D. Skinner's report of 1878; and the quantities marked thus (†) are taken from Assistant J. D. Raynolds's report of 1879. (See reports alluded to.) The quantities are introduced here to show the surplus water passing at Paint Creek dam, the lowest dam in the system, as well as the total supply per second for 90 days, and total cost of dams for the Chippewa River system of reservoirs.

Elevation and slopes on Yellow and Namakagon Rivers.

Point of observation.	Approximate elevation above the sea.	True elevation above the sea.	Fall from last point.	Total fall.	Distance from last point.	Total distance.	Slope per mile from last point.	Slope per mile on total distance.
Yellow River.							*Feet.*	*Feet.*
Mud Lake dam site		1,085						
Rice Lake dam site		969	116	116	20	20	5.8	[illegible]
Yellow Lake dam site		928	41	157	28	48	1.5	[illegible]
Mouth of Yellow River	888		40	197	7	55	5.7	[illegible]
Namakagon River.								
Little Puckwawance		1,218						
Mouth of Chippenacia Creek		1,115	103	103	16	16	6.4	[illegible]
Mouth of Spring Brook		1,068	47	150	6	22	7.9	[illegible]
Mouth of Jordan River		1,058	10	160	1½	23½	6.6	[illegible]
Veazie's dam site		1,039	19	179	8	31½	2.4	[illegible]
Mouth of Stuntz Brook		952	87	266	14½	46	6.0	[illegible]
Mouth of McKenzie Brook		944	8	274	3	49	2.6	[illegible]
Mouth of Totogatic River		918	26	300	10	59	2.6	[illegible]
Lower dam site		917	1	301	1	60	1.0	[illegible]
Mouth of Namakagon River	908		9	310	4	64	2.2	[illegible]

Elevations and slopes on Snake, Kettle, and Clam rivers.

Snake River.								
Mouth of Knife River		964						
Mouth of Ann River		943	21	21	5	5	4.2	[illegible]
Mouth of Ground House		940	3	24	4	9	0.75	[illegible]
At Chengwatana		929	11	35	23	32	0.5	[illegible]
Mouth of Snake River	790		139	174	12	44	11.6	[illegible]
Kettle River.								
Northern Pacific Railroad crossing		1,299						
Willow River, on St. Paul and Duluth Railroad		1,023	276	276	36	36	7.7	[illegible]
Kettle River Station		1,016	7	283	5	41	1.4	[illegible]
Mouth of Kettle River	816		200	483	33	74	6.6	[illegible]
Clam River.								
Limit of proposed reservoir		967						
At dam-site		947	20	20	10	10	2.0	[illegible]
At Saint Croix Road Crossing		881	66	86	13	23	5.0	[illegible]
Mouth of Clam River	866		15	101	6	29	2.5	[illegible]

Elevation of water-surface, at ordinary stage, of various points on the Saint Croix River, with slope per mile.

Upper Saint Croix Lake		1,010						
Mouth of Moose River		1,001	9	9	21	21	0.4	0.4
Mouth of Namakagon River	908		93	102	17	38	5.5	[illegible]
Mouth of Yellow River	888		20	122	12	50	1.7	[illegible]
Mouth of Clam River	866		22	144	12	62	1.8	[illegible]
Head of Kettle River Rapids	850		16	160	9	71	1.8	[illegible]
Mouth of Kettle River	816		34	194	2½	73½	13.6	[illegible]
Foot of Kettle River Rapids	801		15	219	1½	75	10.0	[illegible]
Mouth of Snake River	790		11	230	3	78	3.8	[illegible]
Rush City Ferry		773	17	247	12	90	1.4	[illegible]
Taylor's Falls		679	94	341	30	120	3.1	[illegible]
Stillwater		662	17	358	29	149	0.6	[illegible]

	Elevation in feet.
Water in Lost Lake	1,385.
Water at mouth of Little Chief River	1,287.2
Water in Little Chief River at J. D. Haywood's dam	1,292.7
Water above dam	1,293.8
Water in Crane Lake	1,300.7
Water in Chief Lake	1,295.7
Water in Large Lake, in sections 26, 27, 34, 35, township 40, range 7 west	1,305.9
Water in Small Lake, in sections 34, 35, township 40 north, range 7 west	1,306.9
Water in Pokegama Lake	1,290.5
Water in West Fork Chippewa River above rapids, near dam site	1,286.0

COURTS OREILLES.

Water in Lake Courts Oreilles	1,287.2
Water in Grindstone Lake	1,287.6
Water in Island Lake	1,292.0
Water in lake in sections 34, 35, township 40 north, range 9 west	1,290.6
Water in lake in section 34, township 40 north, range 9 west	1,292.9
Water in Fish Lake	1,288.7
Water in Sand Lake	1,301.1
Water in Little Sand Lake	1,303.8
Water in Flat Lake	1,320.3
Water in Little Courts Oreilles Lake, below dam site	1,286.4
Water in Small Lake, section 33, township 40 north, range 8 west	1,299.7

APPENDIX r.

Table VII.—Chippewa River.

Table of distances from Eau Claire, by water.

To—	Miles.
Paint Creek dam site	19
Pa-kwa-wang dam site	116
Little Chief Lake dam site	116.5
Courtes Oreilles dam site	118
Moose Lake dam site	130.5
Bear Lake dam site	131
Butternut Lake dam site	145
Round Lake dam site	172
Squaw Lake dam site	179.5
Park Lake dam site	191.5
Bear Creek dam site	196.5
Rest Lake dam site	221.5

APPENDIX s.

Table VIII.—Chippewa River.

Table of lengths of "telegraph line" necessary to be constructed to connect the proposed dam sites at the different reservoirs at the sources of the Chippewa River with the nearest telegraph line.

	Miles.
Chippewa Crossing, on line of Wisconsin Central Railroad, to Bear Lake	16
Bear Lake to Little Chief Lake	12
Little Chief Lake to Pa-kwa-wang	3
Pa-kwa-wang to Moose Lake	9
Pa-kwa-wang to Courtes Oreilles	16
Butternut, on line of Wisconsin Central Railroad, to Butternut Lake	6
Fifield, on line of Wisconsin Central Railroad, to Round Lake	17
Round Lake to Squaw Lake	6
Squaw Lake to Bear Creek	12
Bear Creek to Park Lake	9
Bear Creek to Rest Lake	9
Chippewa Falls to Paint Creek	4
Total	119

APPENDIX *t*.

TABLE IX.—CHIPPEWA RIVER.

List of lands and approximate areas which will be overflowed by proposed reservoirs on the Chippewa River and tributaries.

[Omitted. See House Ex. Doc. No. 39, Forty-sixth Congress, second session, pp. 82–94.]

Summary of lands damaged at the reservoirs on the Chippewa River and its tributaries.

Name of reservoir.	Lands belonging to State of Wisconsin.			Lands belonging to private parties and corporations.			United States and Indian reserve lands.		
	Swamp.	School.	Total.	Entered.	Railroad.	Total.	United States.	Indian.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Bear Lake	720.00	120.00	840.00	4,230.00	....	4,230.00	....	....	....
Little Chief Lake	....	....	....	2,693.91	....	2,693.91	....	....	....
Moose Lake	1,000.00	200.00	1,200.00	2,520.00	1,440.00	3,960.00	960.00	....	96[illegible]
Pa-kwa-wang	....	520.00	520.00	5,969.18	7,274.73	13,243.91	1,658.53	7,378.94	9,0[illegible]
Courtes Oreilles	....	286.75	286.75	925.95	3,364.93	4,290.88	2,108.87	3,410.91	5,51[illegible]
Paint Creek	652.54	....	652.54	2,236.56	200.79	2,437.35	....	....	....
Butternut Lake	547.93	....	547.93	1,472.49	607.74	2,080.23	333.10	....	33[illegible]
Park Lake	614.17	....	614.17	121.88	288.90	410.78	2,067.30	....	2,06[illegible]
Rest Lake	217.00	275.00	492.00	3,283.00	41.00	3,274.00	3,657.00	....	3,6[illegible]
Bear Creek	14,164.00	1,699.00	15,863.00	1,320.00	2,521.00	3,841.00	4,842.00	11,687.00	16,5[illegible]
Round Lake	2,750.00	440.00	3,190.00	2,405.00	757.00	3,162.00	604.00	....	6[illegible]
Squaw Lake	1,960.00	425.00	2,385.00	775.00	1,400.00	2,175.00	135.00	240.00	3[illegible]
Total	22,625.64	3,965.75	26,501.39	27,902.97	17,896.09	45,799.06	16,366.00	22,716.85	39,0[illegible]

NOTE.—Approximately correct.

APPENDIX u.

TABLE I.—WISCONSIN RIVER.

Proposed reservoirs—Wisconsin River.

Designation of reservoir.	Location.			Elevation above the sea of low-water surface at dam-site.	Dimensions of dam.		Dimensions of dike.		Area of reservoir.		Capacity of reservoir.	Area of watershed.	
	Section.	Township north.	Range east.		Maximum height.	Length.	Maximum height.	Length.	Square miles.	Square feet.	Cubic feet.	Square miles.	Square feet.
Pelican	6	36	9	1, 520. 83	28	800	15	3, 625	13. 45	374, 964, 480	5, 153, 180, 527	301	8, 391, 398, 400
Sugar Camp	17	39	9	1, 562*	12. 5	235	4	260	5	139, 392, 000	1, 356, 284, 160	60	1, 672, 704, 000
Otter Rapids	36	40	9	1, 578. 07	22	1, 300	5	700	30. 74	856, 982, 016	7, 389, 727, 488	447	12, 461, 644, 800
Tomahawk	7	39	6	1, 554. 67	12	190	......	......	13. 47	375, 522, 048	2, 226, 113, 036	101. 5	2, 829, 657, 600
Squirrel	1	38	5	1, 521. 78	17	315	......	......	5. 30	147, 755, 520	1, 338, 163, 200	56	1, 561, 190, 400
Rice	9	35	6	....	14	1, 100	......	......	6	167, 270, 400	1, 043, 516, 880	396	11, 039, 846, 400
Vieux Desert	17	42	11	....	......	......	......	......	7	195, 148, 800	400, 000, 000	19	529, 689, 600
Twin Lakes	19	41	11	....	......	......	......	......	6. 5	181, 209, 600	650, 000, 000	30	836, 352, 000
				....	......	......	......	......	87. 46	2, 438, 244, 864	19, 556, 985, 291	1, 410. 5	39, 322, 483, 200

*Approximated.

APPENDIX u—Continued.

Designation of reservoir.	Assuming one-third rainfall as available.				Assuming one-fourth rainfall as available.			
	Net annual supply.	Surplus capacity.	Surplus supply.	Amount deliverable per second for 90 days.	Net annual supply.	Surplus capacity.	Surplus supply.	Amount deliverable per second for 90 days.
Pelican	6, 836, 596, 800		1, 683, 416, 273	662. 71	5, 166, 506, 400		13, 325, 873	662. 71
Sugar Camp	1, 335, 840, 000	20, 444, 160		171. 79	1, 016, 400, 000	339, 884, 160		130. 71
Otter Rapids	10, 027, 628, 160		2, 637, 900, 672	950. 82	7, 609, 990, 080		220, 262, 592	950. 32
Tomahawk	2, 201, 580, 480	24, 532, 556		283. 12	1, 690, 302, 240	535, 810, 796		217. 37
Squirrel	1, 239, 427, 200	98, 736, 000		159. 39	944, 961, 600	393, 201, 600		121. 52
Rice	9, 130, 176, 000		8, 086, 659, 120	134. 19	6, 865, 056, 000		5, 821, 539, 120	134. 19
Vieux Desert	360, 096, 000	39, 904, 000		46. 30	290, 400, 000	109, 600, 000		37. 34
Twin Lakes	621, 456, 000	28, 544, 000		79. 92	489, 968, 000	160, 032, 000		63. 01
	31, 752, 800, 640	212, 160, 716	12, 407, 976, 065	2, 487. 74	24, 073, 584, 320	1, 538, 528, 556	6, 055, 127, 585	2, 317. 17

Net supply is, after making allowance for evaporation over reservoir surface, assumed at 25 inches per annum.

Where one-third rainfall is counted on, the formula is: Net supply $= (A - A')\frac{R}{3} + A'\frac{R}{6} = \frac{R}{6}(2A - A')$

A = area of watershed.
A' = area of reservoir.
R = mean annual rainfall = 30 inches.

Where one-fourth rainfall is counted on, the formula is: Net supply $= (A - A')\frac{R}{4} + A'\frac{R}{6} = \frac{R}{12}(3A - A')$

APPENDIX *v*.

TABLE II.—WISCONSIN RIVER.

List of lands and approximate areas which will be overflowed by proposed reservoirs on the Wisconsin River.

[Omitted. See House Ex. Doc. No. 39, Forty-sixth Congress, second session, pp. 98–105.]

SUMMARY BY RESERVOIRS.

Overflowed lands.

Designation of reservoir.	Transferred to State of Wisconsin.	Transferred to private parties and corporations.	Military wagon-road grant.	Chippewa Indian Reservation.	United States public lands.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Pelican	2,500	1,624			8,275
Sugar Camp	1,678	1,270			1,257
Otter Rapids	6,721	6,142	3,456		11,149
Tomahawk	1,223	2,965		996	5,722
Squirrel	3,280	360			1,220
Rice	1,497	648			2,989
Total	16,899	13,009	3,456	996	30,612
Grand total					64,972

NOTE.—Approximately correct.

* * * * * * *

APPENDIX *w*.

RESERVOIRS.

Existing sluicing dams on Chippewa and Wisconsin rivers and tributaries, at or near proposed dam sites, where surveys for reservoirs have been made.

Name of stream upon which located.	Location of dam.	Parties to whom charter was granted.	When granted.
Little Chief River	NE. ¼ section 26, township 40 north, range 7 west.	A. J. Hayward and W. E. McCord.	1879
Round Lake	Section 23, township 40 north, range 3 east.	Henry Hewett and Eric McArthur.	1878
Courtes Oreilles River	East of east line of township 38 north, range 8 west.	Fredric G. Stanley, Emory D. Stanley, Burt E. Reid.	1878
Butternut Creek*	Section 18, township 40 north, range 1 west.		
Bear Lake*	Section 26, township 41 north, range 4 west.		
Near Moose Lake*	Section 14, township 41 north, range 6 west.		
West Fork Chippewa River*	Section 32, township 42 north, range 5 west.		
Outlet of Pokegama Lake*	Section 32, township 40 north, range 6 west.		
Pelican Dam*†	Section 6, township 36 north, range 9 east.		
Otter Rapids*‡	Section 36, township 40 north, range 9 east.		

* Can find no record of charters granted for dams at these locations.
† Flowage on Wisconsin River. ‡ Principal flowage on Eagle River.

APPENDIX x.

RESERVOIRS.

Table of watersheds tributary to the Mississippi River above the Ohio, taken from General Warren's report on bridging the Mississippi River.

Name.	Miles drained.	Total miles drained.	Distance apart.	Total distance.	Right bank.	Left bank.
Minnesota River	310	310			R. B.	
Whetstone or Izuza River	110	420	30	30	R. B.	
Yellow Banks River	340	760	6	36	R. B.	
Pomme de Terre River	960	1, 720	13	49		L. B.
Lac-qui-parle River	830	2, 550	15	64	R. B.	
Chippewa River	1, 970	4, 520	10	74		L. B.
Yellow Medicine River	650	5, 170	20	94	R. B.	
Chetomba or Hawk Creek	470	6, 640	1	95		L. B.
Redwood River	770	6, 410	20	115	R. B.	
Beaver Creek	240	6, 650	2	117		L. B.
Big Cottonwood River	980	7, 630	37	154	R. B.	
Little Cottonwood River	245	7, 875	4	158	R. B.	
Blue Earth River	3, 350	11, 225	16	174	R. B.	
Cherry Creek	57	11, 282	15	189	R. B.	
Little Le Sueur River	144	11, 426	7	196	R. B.	
Rush River	102	11, 528	2	198		L. B.
High Island Creek	75	11, 603	6	204		L. B.
Sand Creek	234	11, 837	18	222	R. B.	
Carver Creek	100	11, 937	1	223		L. B.
Credit River	140	12, 077	15	238	R. B.	
Nine-Mile Creek	42	*12, 119	2	240		L. B.
Mississippi River	21, 600	33, 719	9	249		L. B.
Saint Croix River and Lake	7, 568	41, 287	30	279		L. B.
Vermillion River	237	41, 524	3	282	R. B.	
Trimbelle River	95	41, 619	9	291		L. B.
Cannon River	1, 639	43, 258	5	296	R. B.	
Isabelle River	73	43, 331	5	301		L. B.
Rush River	183	43, 514	4	305		L. B.
Chippewa River	9, 602	53, 116	18	323		L. B.
Beef River	452	53, 568	9	332		L. B.
Zumbro River	1, 366	54, 934	9	341	R. B.	
Whitewater River	382	55, 316	1	342	R. B.	
Eagle Creek	158	55, 474	9	351		L. B.
Rolling Stone Creek	136	55, 610	6	357	R. B.	
Trempeleau River	700	56, 310	10	367		L. B.
Black River	2, 880	59, 190	18	385		L. B.
La Crosse River	463	59, 653		385		L. B.
Root River	1, 685	61, 338	4	389	R. B.	
Raccoon Creek	139	61, 477	7	396		L. B.
Crooked Creek	70	61, 547	3	399	R. B.	
Badaxe River	180	61, 727	7	406		L. B.
Upper Iowa River	939	62, 666	3	409	R. B.	
Paint Creek	70	62, 736	25	434	R. B.	
Yellow River	279	63, 015	4	438	R. B.	
Wisconsin River	11, 850	74, 865	7	445		L. B.
Turkey River	1, 679	76, 544	21	466	R. B.	
Grant River	289	76, 833	13	479		L. B.
Platte River	306	77, 139	6	485		L. B.
Little Makoqueta	150	77, 289	3	488	R. B.	
Catfish Creek	75	77, 364	7	495	R. B.	
Big Menomonee Creek	32	77, 396	4	499		L. B.
Sinsinawa Creek	50	77, 446	4	503		L. B.
Tête de Mort Creek	45	77, 491	1	504	R. B.	
Fever River	185	77, 676	3	507		L. B.
Mill Creek	35	77, 711	7	514	R. B.	
Makoqueta River	1, 863	79, 514	7	521	R. B.	
Apple River	245	79, 819	4	525		L. B.
Rush Creek	85	79, 904	2	527		L. B.
Plum River	280	80, 184	6	533		L. B.
Wapsipinicon River	2, 490	82, 674	28	561	R. B.	
Rock River	10, 690	93, 364	25	586		L. B.
Copperas Creek	25	93, 389	26	612		L. B.
Iowa River	12, 250	105, 639	15	627	R. B.	
Edward's River	43	105, 682	2	629		L. B.
Pope Creek	135	105, 817	4	633		L. B.
Henderson River	625	106, 442	18	651		L. B.
Flint Creek	165	106, 607	4	655	R. B.	

* Total of Minnesota rivers.

Table of watersheds tributary to the Mississippi River above the Ohio, &c.—Continued.

Name.	Miles drained.	Total miles drained.	Distance apart.	Total distance.	Right bank.	Left bank.
Ellison's Creek	104	106, 711	3	658	......	L. B.
Honey Creek	65	106, 776	5	663	......	L. B.
Skunk River	4, 322	111, 098	1	664	R. B.	......
Sugar Creek	150	111, 248	18	682	R. B.	......
Des Moines River	14, 955	126, 203	32	714	R. B.	......
Fox River	479	126, 682	4	718	R. B.	......
Bear Creek	418	127, 100	15	733	......	L. B.
Wyaconda Creek	480	127, 580	5	738	R. B.	......
Fabius River	1, 590	129, 170	13	751	R. B.	......
North River	465	129, 635	2	753	R. B.	......
Mill Creek	96	129, 731	3	756	......	L. B.
McDonald's Creek	140	129, 871	13	769	......	L. B.
Salt River	2, 741	132, 612	18	787	R. B.	......
Noix Creek	52	132, 664	3	790	R. B.	......
Buffalo Creek	40	132, 704	1	791	R. B.	......
Bobb's Creek	90	132, 794	13	804	R. B.	......
Gwinn's Creek	25	132, 819	2	806	R. B.	......
Bryant's Creek	75	132, 894	19	825	R. B.	......
Cuivre Creek	1, 180	134, 074	9	834	R. B.	......
Perogue Creek	90	134, 164	3	837	R. B.	......
Dardenne Creek	110	134, 274	6	843	R. B.	......
Illinois River	27, 465	161, 739	8	851	......	L. B.
Big Piasa Creek	100	161, 839	10	861	......	L. B.
Missouri River	518, 000	679, 839	10	871	R. B.	......
Wood River	145	679, 984	......	871	......	L. B.
Cahokia Creek	400	680, 384	17	888	......	L. B.
Meramec River	3, 715	684, 099	18	906	R. B.	......
Eagle Creek	70	684, 169	7	913	......	L. B.
Platin Creek	110	684, 279	5	918	R. B.	......
L'isle de Bois Creek	50	684, 329	9	927	R. B.	......
Establishment River	110	684, 439	6	933	R. B.	......
Rivière aux Vases	100	684, 539	4	937	R. B.	......
Saline River	240	684, 779	12	949	R. B.	......
Kaskaskia River	5, 660	690, 439	7	956	......	L. B.
Saint Mary's River	215	690, 654	4	960	......	L. B.
Brazos Creek	40	690, 694	24	984	R. B.	......
Big Muddy River	2, 245	692, 939	6	990	......	L. B.
Apple Creek	200	693, 139	1	991	R. B.	......
Clear Creek	135	693, 274	18	1, 009	......	L. B.
Ohio River	....	....	42	1, 051	......	......

U 9.

EXPERIMENTAL DAM AT LAKE WINNIBIGOSHISH.

Congress, by act approved June 14, 1880, appropriated:

For the reservoirs at the headwaters of the Mississippi River, to be used in the construction of a dam at Lake Winnibigoshish, seventy-five thousand dollars: *Provided*, That all injuries occasioned to individuals by overflow of their lands shall be ascertained and determined by agreement, or in accordance with the laws of Minnesota, and shall not exceed in the aggregate five thousand dollars.

An examination of the site was made during the month of June, last, and data collected from which to prepare detailed plans, drawings, and estimates. It is proposed, with the funds appropriated, to construct a dam of timber and earth, to have a lift of about 16 feet above low-water; the work to be performed by day labor and purchase of materials in open market, it not being possible to predict quantities of material, or insure no variation in mode of construction, from day to day, so as to warrant entering into contract for the same. It is expected that the amount appropriated will complete this dam; hence, no estimate is rendered for future work. As the appropriation for this dam may be regarded as the initiative for a trial of the proposed reservoir system at the sources of the Mississippi, Saint Croix, Chippewa, and Wisconsin

rivers, to ameliorate the damage from floods, and to improve the low-water navigation of those streams, and ultimately of the Mississippi River for some distance below Saint Paul, it will, in addition to the maintenance and operation of this dam, be necessary to observe its effect upon a limited portion at least of the river below it. To carry this out and care for the "plant" will require for the fiscal year ending June 30, 1882, at least $6,000. In the original estimates for the reservoirs it is assumed that for the first ten years the dams, if well built, can be kept in repair for 15 per cent. of their original cost. The sum above named is far below the 15 per cent. It is probable that a special report upon this work will be submitted in time for the consideration of the next Congress. No important benefits to navigation or other interests can be expected from this single dam.

This work is in the collection district of Minnesota. Duluth, Minn., is the nearest port of entry, at which place the revenues collected for the fiscal year ending June 30, 1880, amounted to $1,9 64.5

Money statement.

Amount appropriated by act approved June 14, 1880	$75,000 00
July 1, 1880, amount available	75,000 00

U 10.

SURVEY OF THE MISSISSIPPI RIVER FROM SAINT PAUL TO THE FALLS OF SAINT ANTHONY, MINNESOTA.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., April 15, 1880.

GENERAL: I have the honor to present the following report of survey of the Mississippi River from Saint Paul to the Falls of Saint Anthony, made in obedience to the requirements of section 2, act of Congress, approved March 3, 1879:

* * * * * * *

No continuous government survey of this piece of river seems to have been made since 1867, so that the maps now presented are valuable as showing its condition to date.

The survey extended from the lower highway bridge, at Minneapolis, to the Saint Paul and Sioux City Railroad Bridge, at Saint Paul, a distance of about 13 miles. The approximate low-water fall between these points is 45 feet.

The channel between Minneapolis and Saint Paul is divided by several islands, and occupied by log and sheer booms, cribs, &c. Just above the junction of the stream with the Minnesota River is the Fort Snelling Bridge. A few miles above this bridge is the site of the bridge (under construction) of the Chicago, Milwaukee and Saint Paul Railway Company. The channel at low-water is very shoal, and the bed of the river, for several miles below Minneapolis, paved with water-logged slabs and edgings, refuse from the mills at Minneapolis. There is no steamboat traffic between Saint Paul and Minneapolis, excepting that occasionally a small light-draught steamer makes an excursion as far up as Fort Snelling. Therefore, no estimates for improvement are submitted herewith.

Congress, by act approved July 23, 1868, granted to the State of Minnesota certain sections of public lands to aid in the construction of a

lock and dam at Meeker's Island. Subsequently, by act approved March 3, 1873, Congress appropriated towards the construction of the lock and dam the sum of $25,000, with the proviso:

That all rights and claims in and to the land-grant made to the State of Minnesota for the above work by act approved July 23, 1868, shall be fully relinquished to the United States before any of this appropriation is expended.

No satisfactory relinquishment has as yet been made to the United States.

The report of Assistant Terry, together with two tracings of map of survey on scale of 1 inch to 400 feet, is submitted herewith.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. FREDERICK TERRY, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., April 12, 1880.

SIR: I respectfully submit the following report of the survey of the Mississippi River from Saint Paul to the Falls of Saint Anthony.

In obedience to your instructions, I commenced work at Minneapolis on October 27, 1879, with Messrs. J. B. Parkinson and E. A. Guill as assistants, and a force of twelve laborers. The field of work was between points established by previous United States surveys at Minneapolis and the survey made under direction of Maj. F. U. Farquhar, which had been brought up the river as far as the Sioux City Railroad Bridge. The distance between these points was found to be 13¼ miles. The work was completed and the laborers discharged on November 11, 1879.

The channel of the river is divided by a number of islands and bars, these last consisting principally of sawdust and edgings from the saw-mills at Minneapolis, with some gravel and small rocks.

The current of the river is very rapid through nearly the whole distance covered by the survey, and above Meeker's Island the current was found too swift to sound with any of the appliances at my command. The river below this point was sounded without trouble.

The slope of the river from the lower bridge at Minneapolis to the Sioux City Railroad bridge at Saint Paul is about 45 feet at a 2-foot stage. It was found impossible to arrive at an exact determination of the slope on account of the fluctuation of the water, due to the manipulation of the sluice-gates of the water power at Minneapolis.

It was proposed some years ago to construct a lock and dam at Meeker's Island for the purpose of extending navigation to the foot of the Falls of Saint Anthony, and a survey was made in 1873 to base an estimate of the expense of such a work, but the cost was found to be so great that nothing has ever been done towards its construction. I present no plan for the improvement of that portion of the river covered by the survey, as there is no commerce above Saint Paul, and the expense of any such improvement would be out of proportion to any benefits it would at present confer.

Very respectfully, your obedient servant,

FREDERICK TERRY,
Assistant Engineer.

Capt. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

U II.

SURVEY OF SAINT CROIX RIVER FROM TAYLOR'S FALLS, THE HEAD OF STEAMBOAT NAVIGATION, TO PRESCOTT.

ENGINEERS OFFICE, UNITED STATES ARMY,
Saint Paul, January 26, 1880.

GENERAL: I have the honor to report the results of a survey of the Saint Croix River, Minnesota and Wisconsin, made in accordance with

authority from the Chief of Engineers, as per letters of the 14th and 23d of May, 1879.

Early in August, as soon as the stand of water approached the low-water stage, a party was organized and placed in charge of Assistant Engineer Frederick Terry, assisted by Messrs. J. B. Parkinson and E. A. Guill, assistant engineers, to survey the river from Taylor's Falls, the head of steamboat navigation, to Prescott, at the confluence of the Saint Croix and the Mississippi, the total distance being about 52 miles. The operations of the survey consisted in the usual triangulation, meanderings, soundings, and gaugings of the discharge; in addition, full lines of level were run over the entire distance, giving the fall. The levels are all referred to sea-level. The party returned to this city on the 24th of October, 1879, having satisfactorily performed the duties required, and was immediately transferred to the survey of the Mississippi between Saint Paul and the Falls of Saint Anthony, said survey having been ordered by section 2, act of Congress approved March 3, 1879. It was considered as in the interest of economy to thus transfer the party. Upon the completion of the latter-named survey, the party returned to Saint Paul and projected maps of the Saint Croix River.

The course of the Saint Croix between Taylor's Falls and Prescott is unusually direct for a stream flowing over an alluvial bed. But few curves occur. The material composing the bed is sand, gravel, some bowlders, and some clay. The banks are subject to wash. The channel is divided by a large number of islands, forming secondary channels, chutes, and sloughs, which are largely utilized by the logging interests for storage and distribution of logs. The banks are, alternately, bottom and bluff; the former about 8 to 10 feet above low-water; the latter rising as high as 150 feet. At the Dalles the trap rock rises precipitously from the water's edge. The river is fed by numerous streams ranging from the smallest creeks upwards. The Apple and Kinnickinnick rivers contribute large quantities of gravel, and all of them more or less gravel, sand, and mud. As might be expected, frequent changes in the channel have occurred, especially after the spring freshets. The low-water volume at Taylor's Falls is about 1,900 cubic feet per second; at McLeod's Lake, about 14 miles below the falls, it is 2,300 cubic feet per second; and at the foot of the lake about 2,800 cubic feet per second.

The average low-water slope from Taylor's Falls to Stillwater, at the head of the lake, is 0.605 foot per mile.

The range of water surface at Taylor's Falls Landing, below the Dalles is 11 feet; at Stillwater, 16 feet; and at Prescott, where the Mississippi exerts a strong influence, it is about 22 feet. The stage of water in the river is much affected, also, by the operations of the dams above the Dalles, these dams being used by loggers for the purpose of creating a driving stage for logs. This has, however, been referred to in my report of December 9, 1878, upon the Saint Croix.

The obstructions to navigation, viz, piers, snags, leaning trees, bowlders, sand-bars, &c., are also referred to in that report and in preceding ones.

The stream is navigated by steamers and barges; and, in addition, by rafts below Stillwater.

Three feet to 3½ feet depth in the channel at lowest water generally satisfies the wants of steamers plying above Stillwater. To insure the depth required the low-water width of the stream must be contracted at a number of points to 400 feet.

The survey commenced at the Dalles Bridge, although a bench mark was established at a point on the Minnesota side about 4,000 feet above

the bridge. From that point to the Taylor's Falls Landing, a distance of about 5,600 feet, the fall of the low-water surface was ascertained to be 19.27 feet; the greater part of the fall accumulating at the portion of the Dalles spanned by the bridge.

During the earlier period of the survey and until McLeod's Lake was reached the stage of water averaged 2.6 feet above low-water; during the rest of the survey the gauge indicated about 6 inches above that plane. The actual soundings are plotted, but the curve projected on the maps herewith in red is a 3-foot curve reduced to low-water. Much of the good depth of water indicated on the maps is due to the removal of obstructions and other work performed by the United States in 1878 and 1879.

The first place below the Dalles where shoal water was found during the survey is in the vicinity of Islands 1 and 2 (see map). Between Island No. 2 and the right bank is a channel known as Clark's Slough, which, although incumbered more or less by old cribs, &c., has for several seasons possessed better depth of water than the lefthand channel. A large number of cribs and other obstructions was removed by the United States in 1878, and the material utilized in the repair and extension of the wing-dam at the upper end of the island (shown in black on the map). The right bank of the island was also revetted during the same season. The result has been a good channel. After heavy storms in summer, however, the torrents issuing through the ravines leading from the bluffs on the right bank carry sand into this channel, a notable instance of such action having occurred during the season of 1879. To keep this channel up to its maximum usefulness will require the construction of the small dam between the island and the tow-head, and, probably, about 200 linear feet of brush and stone wall at the lower end of the island, as shown in red on the map. The current evinces a tendency to set in behind Island No. 1, above, enlarging the chute and disturbing the existing state of affairs in this locality. A dam 850 feet in length is projected to close this chute.

Proceeding down stream we come to Island No. 3, between which and the left bank of the mainland is a channel about 150 feet in width. To serve the double purpose of diverting the water from this channel and of maintaining the low-water width in the main channel at 400 feet, a jetty 600 feet in length is projected.

Good depth of water was found from this last-named point down to the head of Island No. 5, or Boom Island. The current above the head of the island sets strongly against the left bank, which is protected by a revetment constructed in 1878 about 1,100 feet in length, and by a low dam just below the point 300 feet in length. The channel behind Boom Island was at one time partially closed by *débris* of cribs, &c., but the floods of last season swept the material away, so that there is strong probability of a large volume of water taking this channel. To prevent such, and maintain the depth in the main channel, a dam 620 feet in length is proposed. A dam 200 feet in length across the slough, left bank, above Franconia, will assist in maintaining a good depth over this stretch of river.

Just below Boom Island are the Osceola Islands 7, 8, 9, and 10. The steamboat channel here is along the left bank and in front of Osceola. It can be seen by the map that a large body of water flows behind Nos. 8, 9, and 10, to prevent which, as well as to maintain the depth necessary in the main channel, a series of dams, in all 1,425 feet in length, is proposed.

About 1 mile below Osceola are Islands Nos. 12 and 13, the latter

known as Mile Island. The channel at this locality changed in direction, following the high-water of last spring, and now passes to the left of Mile Island. One of the channels must be closed; probably the right-hand one. Two dams, of total length 800 feet, are proposed.

I may state here that all the dams and jetties proposed are not to have their upper surfaces more than 2 feet above low-water, and that their locations and dimensions are but approximate, as the channel may change before they can all be constructed.

About half a mile below Mile Island is the Limekiln Crossing, where trouble is frequently experienced by steamers at low-water stage. To contract the water-way here about 550 linear feet of brush and stone work will be necessary.

Just above Island No. 14 a dam or jetty 450 feet in length will be required.

Passing Island No. 16, the locality known as Cedar Bend is reached. The channel at this point has at times passed behind Islands 17 and 18. The channel marked as the East Slough also abstracts some of the volume of the river, and a large portion of the volume of discharge goes behind Island 19. The banks of the latter island and of the large island above it are cutting rapidly. About 1,550 linear feet of dams will be required here, and also about 1,000 linear feet of shore protection.

After leaving Cedar Bend no difficulty in navigation is experienced until reaching the foot of McLeod's Lake, where the width of stream increases, with a shoal-crossing. At this point, owing to the direction of the current, four short spurs on the left bank, aggregating in length 675 feet, will, it is thought, prove sufficient.

At Island 21 there is a shoal stretch of river, owing to the increased channel width. A series of dams and spurs, aggregating about 700 linear feet, is here proposed.

Just above the head of Island 22 (Pine Island) the channel again shoals. The channel appears to be changing in direction at this point, making towards the right bank, whence it will probably cross again to the opposite bank. It is probable that a jetty 600 feet long, as indicated on the map, will be required here. About opposite the middle of the island, the crossing, during the latter part of the season of 1879, was unusually shoal. This crossing was so improved by the construction of a jetty that no further work will probably be required here. The shore of Pine Island was revetted for a distance of 800 feet. The channel depth is now not less than 5 feet. The old line of piling below the jetty, shown by dotted black line, and the hard bars surrounding it aid in maintaining the flow of water along the right bank. Previous to the construction of the jetty we afforded some aid to steamers by scraping a temporary channel at the crossing.

The channel is generally good from this latter point, excepting at Island 25, where 250 feet of dam will be required, to the mass of islands and minor channels above Arcola, known as Page's Slough.

A large portion of the volume of discharge is diverted from the main river through these small channels, and the closure of a sufficient number of them by dams, as indicated on the map, will probably suffice for this portion of the river. Total length of dams about 400 feet.

Below Arcola, and as far down as Island No. 32, the channel is divided by islands. About 1,375 linear feet of dams required.

Between Islands 34 and 35 and the left bank is what is known as the Canal, a deepening of a secondary channel in 1867 by the logging interests for the benefit of steamers when the main river at this point is closed by booms and running logs. This canal is frequently used by steamers when logs run in great numbers. It is, however, narrow, and

in some parts quite shoal. No estimate is rendered herewith for widening or deepening this canal, as it is the work of private parties, although opened by them to the public. No particular contraction of the river at this point appears necessary at present. The booms thrown across the river from this point for some miles above and below and the running of logs have always interfered with steamboat traffic more or less; but a more judicious location of pockets for the storage and assorting of logs has been made during the past season, lessening the difficulties of navigation in a degree. A few old cribs, piles, &c., may eventually require removal at this locality.

From the foot of the canal to Stillwater, the channel is at present a good one. Just above Stillwater the main channel passes between Islands 43, 44, 45, and the left bank, bordered by high and firm bluffs; thence to the Stillwater wharf. Some interests desire the closing of the present (east) channel so as to deepen the west channel, in the hope of deepening the water along the Stillwater front. As such procedure would be attended with doubtful results, it does not seem advisable to go to such expense so long as a good channel (the east) already exists. The channels may of themselves change as desired in the course of years, though there are no indications at present of such change. Some few snags, &c., yet remain to be removed from the east channel, and the gaps between Islands 43, 44, and 45 may require closing by another season. Some revetment will also, probably, be necessary to preserve the islands which now bound the east channel; probably 300 linear feet of dams and 700 linear feet of revetment.

Stillwater is at the head of the Lake Saint Croix. The lake is here spanned by a bridge, with ponton draw nearly 300 feet in the clear. The lake is about 23 miles long, averaging a little more than three-fourths of a mile in width. Its depth, excepting at the bars to be noted further on, is from 30 feet to 50 feet.

Just above Hudson, and about 6 miles below Stillwater, the lake is spanned by the Chicago, Saint Paul and Minneapolis line of railway bridge. The approach to the bridge consists of a long and high embankment, which infringes upon the width of the lake at least 1,200 feet. The bridge consists of one span about 140 feet in the clear at low-water, and a draw with spans of about 140 feet each in the clear. By reference to the map it will be seen that the draw-pier is badly located with reference to the direction of current, and that, in order to facilitate the passage of the west draw-span by rafts and steamers, a sheer-boom or line of piling should extend above the draw, and nearly on the prolongation of the axis of the draw-pier, or at least 1,000 feet, and some projecting points of bar be removed. No estimate is rendered for this, as it seems work pertaining to the bridge company.

The railroad embankment crosses a portion of what is known as Willow River Bar, a bar extending across the greater part of the lake just below the bridge, and for more than a mile down the lake measured from the draw. The main channel, after passing the draw, lies along the right bank, and is narrow and tortuous. This bar was no doubt originally caused by contributions of material from Willow River, brought down by floods. Of late years Willow River has been closed by a dam in order to create water-power, thus arresting its contributions. It is thought that by dredging the material between the line A B (see map) and the right bank so as to afford a depth of 4½ feet, relief will be experienced for a number of years to come.

Material to be removed, sand, gravel, clay, and a few bowlders.

Estimate, 36,000 yards, at 30 cents per yard $10,800

About 6 miles below Hudson Bridge is Catfish Bar, making out in a long spit from the left bank. The channel is narrow, and has sufficient depth, but when strong winds prevail its passage is troublesome to steamers, and especially to rafts. It is thought that by dredging out the prism of material bounded by the line C D on one side and the curved red line on the other to a depth of 4½ feet, sufficient room will be afforded for a number of years to come. If it is found that Bowles' Creek contributes enough material to form the bar again, a curved dike, as indicated on the map in dotted red, can be established to train the material into deep water and out of the way; or a position for a dam, or other works, to arrest the movement of the material, may possibly be found within the limits of the creek itself.

Material of bar, sand, gravel, clay, bowlders.

Quantity to be removed, 20,000 cubic yards, at 30 cents per yard............ $6,000

About 5½ miles below Catfish Bar is Kinnickinnick Bar, doubtless due to contributions of material from the Kinnickinnick River, which enters from the left bank. The channel which lies to the westward of the bar is 500 feet in width and with good depth throughout. Unless this bar increases in width rapidly, nothing will be required at this point in the shape of improvement of navigation for many years to come.

A system of lights at Kinnickinnick, Catfish, and Willow River bars, as well as at some few other points below Stillwater, is earnestly desired by those who navigate the lake.

Prescott, at the foot of the lake, is 6 miles below Kinnickinnick Bar. Nothing seems to be required here.

RECAPITULATION OF ESTIMATES.

11,800 linear feet of dams and jetties, averaging per linear foot $2.75	$32,[illegible]
2,000 linear feet of shore protection, at $4	8,[illegible]
56,000 cubic yards of dredging, at 30 cents	16,[illegible]
Removing snags, stumps, leaning trees, old piers, &c	3,[illegible]
	60,[illegible]

The sum of $25,000 can be profitably expended during the fiscal year ending June 30, 1881.

Brush of proper size for the construction of dams cannot always be obtained in sufficient quantity in the immediate vicinity of a work.

Edgings from saw-mills have been used for the base of the revetment at Marine Bar, and, from the experience in using them thus far, they promise good results. The edgings are about 12 feet long and are made up into fascines, and from these, rafts or mats are made and sunk into position.

As regards the position of a wing-dam, or jetty, with reference to the current of the stream, considerable diversity of opinion exists. It would seem that no especial rule can be strictly followed. Dams projected in a direction normal to the shore line being shortest, require less material. Dams inclined downstream are subject to scour along the upstream face, besides protecting the shore just below their junction with it, less than those do which are inclined upstream. Dams inclined upstream, however, are subject to scour along the lower face. All three types must resist effect of overfall and scour around their heads. In the case of a stream like the Saint Croix, where many millions of logs are run down, it seems better to incline the dams downstream generally, as such tend to sheer the logs into the main channel as the water subsides, keeping the logs from stranding upon them. There are several notable

instances on this river of the effect of lines of piling inclined down-stream to support booms placed for the purpose of guiding logs into the channel desired. A large sand-bar has almost invariably formed just underneath the line of piles, forming, with the piles themselves, a compact inclined jetty. The formation of a sand-bar below a line of piling is not, however, a matter of such certainty as to warrant the rejection of permanent brush and stone work.

Appended is a list of distances; also, statistics of the river; and, accompanying, are six tracings, on a scale of 1 inch to 400 feet, showing the stream from Taylor's Falls to Prescott; also, one tracing showing cross-sections of dams and revetments constructed by the United States on the Saint Croix and Chippewa rivers, and which have endured well; also, tracing showing effect of jetties with different inclinations taken from a work on the improvement of the Rhine.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Table of distances on Saint Croix River, commencing at Taylor's Falls Bridge.

Island No.	Miles.	Island No.	Miles.	Island No.	Miles.
1	0.7	16	9.5	31	22.3
2	1.3	17	9.9	32	22.9
3	2.1	18	10.0	33	23.7
4	2.5	19	10.1	34	24.5
5 (Boom)	5.3	20	12.3	35	24.7
6	5.6	21	13.9	36	25.4
7	6.0	22 (Pine)	15.1	37	25.6
8	6.4	23	16.0	38	25.9
9	6.6	24	17.0	39	26.0
10 (Osceola)	6.7	25	19.3	40	26.1
11	7.4	26	20.5	41	26.4
12	7.8	27	20.8	42	26.7
13 (Mile)	8.0	28	21.2	43	27.0
14	9.3	29	21.4	44	27.1
15	9.4	30	21.7	45	27.2

	Miles.
To Stillwater Bridge	28.5
To Hudson Bridge	34.5
To Catfish Bar	40.1
To Kinnickinnick Bar	45.7
To Prescott	51.7

COMMERCIAL STATISTICS.

The Saint Croix River is in the collection district of Minnesota. The nearest port of entry is that of Duluth, Minn., at which port $7,764.51 of revenue was collected for the fiscal year ending June 30, 1879.

FREIGHT AND PASSENGERS.

There were three steamboats engaged exclusively in the freight and passenger business during the season of 1879, and from the statement it will be seen that the business done was large, when we take into consideration the length of river traversed—less than 60 miles. Of the three steamboats engaged, two plied between Hastings and Taylor's Falls, and commenced running on the opening of navigation; and the other between Stillwater and Taylor's Falls, and commenced running about August 1.

About 6 miles below Hudson Bridge is Catfish Bar, making out in a long spit from the left bank. The channel is narrow, and has sufficient depth, but when strong winds prevail its passage is troublesome to steamers, and especially to rafts. It is thought that by dredging out the prism of material bounded by the line C D on one side and the curved red line on the other to a depth of 4½ feet, sufficient room will be afforded for a number of years to come. If it is found that Bowles' Creek contributes enough material to form the bar again, a curved dike, as indicated on the map in dotted red, can be established to train the material into deep water and out of the way; or a position for a dam, or other works, to arrest the movement of the material, may possibly be found within the limits of the creek itself.

Material of bar, sand, gravel, clay, bowlders.

Quantity to be removed, 20,000 cubic yards, at 30 cents per yard............ $6,[illegible]

About 5½ miles below Catfish Bar is Kinnickinnick Bar, doubtless due to contributions of material from the Kinnickinnick River, which enters from the left bank. The channel which lies to the westward of the bar is 500 feet in width and with good depth throughout. Unless this bar increases in width rapidly, nothing will be required at this point in the shape of improvement of navigation for many years to come.

A system of lights at Kinnickinnick, Catfish, and Willow River bars, as well as at some few other points below Stillwater, is earnestly desired by those who navigate the lake.

Prescott, at the foot of the lake, is 6 miles below Kinnickinnick Bar. Nothing seems to be required here.

RECAPITULATION OF ESTIMATES.

11,800 linear feet of dams and jetties, averaging per linear foot $2.75........	$32,[illegible]
2,000 linear feet of shore protection, at $4..............................	[illegible]
56,000 cubic yards of dredging, at 30 cents..............................	16,[illegible]
Removing snags, stumps, leaning trees, old piers, &c.....................	[illegible]
	60,[illegible]

The sum of $25,000 can be profitably expended during the fiscal year ending June 30, 1881.

Brush of proper size for the construction of dams cannot always be obtained in sufficient quantity in the immediate vicinity of a work.

Edgings from saw-mills have been used for the base of the revetment at Marine Bar, and, from the experience in using them thus far, they promise good results. The edgings are about 12 feet long and are made up into fascines, and from these, rafts or mats are made and sunk into position.

As regards the position of a wing-dam, or jetty, with reference to the current of the stream, considerable diversity of opinion exists. It would seem that no especial rule can be strictly followed. Dams projected in a direction normal to the shore line being shortest, require less material. Dams inclined downstream are subject to scour along the upstream face, besides protecting the shore just below their junction with it, less than those do which are inclined upstream. Dams inclined upstream, however, are subject to scour along the lower face. All three types must resist effect of overfall and scour around their heads. In the case of a stream like the Saint Croix, where many millions of logs are run down, it seems better to incline the dams downstream generally, as such tend to sheer the logs into the main channel as the water subsides, keeping the logs from stranding upon them. There are several notable

instances on this river of the effect of lines of piling inclined downstream to support booms placed for the purpose of guiding logs into the channel desired. A large sand-bar has almost invariably formed just underneath the line of piles, forming, with the piles themselves, a compact inclined jetty. The formation of a sand-bar below a line of piling is not, however, a matter of such certainty as to warrant the rejection of permanent brush and stone work.

Appended is a list of distances; also, statistics of the river; and, accompanying, are six tracings, on a scale of 1 inch to 400 feet, showing the stream from Taylor's Falls to Prescott; also, one tracing showing cross-sections of dams and revetments constructed by the United States on the Saint Croix and Chippewa rivers, and which have endured well; also, tracing showing effect of jetties with different inclinations taken from a work on the improvement of the Rhine.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Table of distances on Saint Croix River, commencing at Taylor's Falls Bridge.

Island No.	Miles.	Island No.	Miles.	Island No.	Miles.
1	0.7	16	9.5	31	22.3
2	1.3	17	9.9	32	22.9
3	2.1	18	10.0	33	23.7
4	2.5	19	10.1	34	24.5
5 (Boom)	5.3	20	12.3	35	24.7
6	5.6	21	13.9	36	25.4
7	6.0	22 (Pine)	15.1	37	25.6
8	6.4	23	16.0	38	25.9
9	6.6	24	17.0	39	26.0
10 (Osceola)	6.7	25	19.3	40	26.1
11	7.4	26	20.5	41	26.4
12	7.8	27	20.8	42	26.7
13 (Mile)	8.0	28	21.2	43	27.0
14	9.3	29	21.4	44	27.1
15	9.4	30	21.7	45	27.2

	Miles.
To Stillwater Bridge	28.5
To Hudson Bridge	34.5
To Catfish Bar	40.1
To Kinnickinnick Bar	45.7
To Prescott	51.7

COMMERCIAL STATISTICS.

The Saint Croix River is in the collection district of Minnesota. The nearest port of entry is that of Duluth, Minn., at which port $7,764.51 of revenue was collected for the fiscal year ending June 30, 1879.

FREIGHT AND PASSENGERS.

There were three steamboats engaged exclusively in the freight and passenger business during the season of 1879, and from the statement it will be seen that the business done was large, when we take into consideration the length of river traversed—less than 60 miles. Of the three steamboats engaged, two plied between Hastings and Taylor's Falls, and commenced running on the opening of navigation; and the other between Stillwater and Taylor's Falls, and commenced running about August 1.

The figures below were furnished by Capt. John H. Reaney, of Saint Paul, Minn., and Capt. David Hays, of Osceola Mills, Wis., under whose directions the boats were operated.

Commodities.	Number of pounds carried up-stream.	Number of pounds carried down-stream.	Total number of pounds carried.
Flour	7,490,000	810,600	8,300,600
Wheat	17,244,000	8,207,895	25,451,[illegible]
Merchandise, &c	9,343,400	2,486,000	11,829,4[illegible]
Lime	868,800	1,074,300	1,943,1[illegible]
Bran and feed	87,500	....	87,5[illegible]
Barley	....	60,000	60,0[illegible]
Oats	....	24,500	24,5[illegible]
Salt	90,000	....	90,00[illegible]
Total	35,123,700	12,663,295	47,786,[illegible]

Passengers carried up and down stream, number, 9,244.

LOGS, LUMBER, RAFTING, AND TOWING, SEASON OF 1879.

Logs.—About 202,000,000 feet of logs passed through the Saint Croix boom during the season, which, at an estimated value of $8 per thousand feet, would represent the sum of $1,616,000. At the boom about 300 men were employed for 100 days.

Lumber.—There are ten large saw-mills on the Saint Croix River, seven of which are located at and around Stillwater, the head of Lake Saint Croix, and engaged in the manufacture of lumber. These seven mills cut during the season:

Lumber	feet..	83,727,[illegible]
Shingles		40,258,[illegible]
Lath		27,600,[illegible]

The estimated value of these products is about $1,170,000. Expense attached to manufacturing the above, $200,000. The other three mills are located at Franconia, Marine, and Glenmore. The amount of their business has not been obtained, but 8,000,000 feet would be a low estimate of the amount of lumber manufactured.

Rafting.—This branch of business requires a large force of men, carried on, however, during only a portion of the season. The amount of lumber rafted foots up 102,000,[illegible] feet.

Towing.—There were twelve steamboats engaged in the towing of lumber and logs to various points during the season. The amount towed was 117,000,000 feet.

APPENDIX V.

IMPROVEMENT OF TENNESSEE AND CUMBERLAND RIVERS AND OF RIVERS IN EASTERN TENNESSEE AND GEORGIA.

REPORT OF MAJOR WILLIAM R. KING, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., July 28, 1880.

GENERAL: I have the honor to submit annual reports on the works under my charge for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

CHIEF OF ENGINEERS, U. S. A.

V 1.

IMPROVEMENT OF TENNESSEE RIVER.

I.—ABOVE CHATTANOOGA.

This section of the river extends from Chattanooga to Knoxville, a distance of 189 miles by water, and the improvement required, and which has been in progress nine years, consists in excavating rock reefs and gravel bars from the channel and narrowing the channel at shoal places by stone wing-dams, thus giving increased depth and securing a navigable channel for steamboats of 3 feet draught at all seasons of the year.

There are in all twenty-nine obstructions (reported as such by steamboat men) on this portion of the river, twenty of which have been either entirely removed or so far improved as to be of secondary importance, and nine remain to be completed.

The last appropriation for this section of the river was all expended on Chota and Coulter's Shoals, the former of which has heretofore been the most serious obstruction between Knoxville and Loudon. The following are the quantities of work done:

Rock excavated from channel	cubic yards..	15
Gravel excavated from channel	do......	53
Drift removed from channel	cords..	35
Rock quarried for dams	cubic yards..	4,374
Rock placed in dams	do......	5,182

The work is done in the most substantial and economical manner, but owing to the small amount of the annual appropriations, which do not

admit of a full season's work, it will probably cost more than the original estimates, which contemplated that work would be carried on continuously during the low-water season, when it could be done to the best advantage.

As heretofore, the work has been done by hired labor. The contract system has been thoroughly tested on this improvement and proved an utter failure, as I believe it has been and always will be on all similar works.

The working season of 1879 commenced on the 14th day of August, and ended on the 18th day of December, when it was interrupted by high-water, an average force of eighty-five men being employed during that period.

The appropriation for 1880 not being available before the end of the fiscal year, and there being only a small balance of the former appropriation on hand, the work has not been resumed this season, but it is hoped that we may still be able to put on a force in time to accomplish considerable work before the end of the low-water season.

The appropriation of June 14, 1880, will probably be sufficient to complete all that it is necessary to do at Chota, Coulter's, and one or two other shoals between Knoxville and Loudon, and make some repairs at Half Moon Island and a few other points where the floods have caused some damage to the dams.

As stated in former reports, the improvements are not only remarkably successful in accomplishing the object in view, but from the exceptionally permanent nature of the river bed and from the fact that the dams are made almost entirely of stone, the work will last for many years with but slight expense for repairs.

The estimate for next year is for continuing the improvement of the river below Knoxville, where there are a number of shoals that have not been worked on, but which must be improved in order that the increased depth of channel already provided at most of the shoals can be fully utilized.

The river-gauge established at Chattanooga in 1874 is now read by the signal observer at this place, Mr. B. L. Goulding, who furnishes a copy of the record for this office, and while parties are working in the river at Muscle Shoals he sends a daily report to each assistant engineer, which is valuable in warning them of sudden rises.

By taking an average of the daily records for the last six years, it is found that there are in each year—

About 100 days when the river is above 8 feet.
About 150 days when the river is above 6 feet.
About 220 days when the river is above 4 feet.
About 325 days when the river is above 2 feet.

In other words, the last figures given show that there are only forty days in a year when the river is within 2 feet of low-water mark. There are only ninety-five days in a year when it falls below 3 feet. The period of highest water is in March and of lowest in October. Some of our principal northern water routes are absolutely closed by ice for a much longer period than the Tennessee River is below 3 feet at Chattanooga. The Erie Canal, for example, in an average of twenty-four years, was closed one hundred and forty-six days annually, or almost exactly the number of days that the Tennessee is below 4 feet. This shows not only the great advantages of this river for purposes of navigation, but the comparatively short time available for channel work.

The amount of commerce on the river during the year is indicated by the following figures relating to the landing at Chattanooga:

Number of steamboats running	8 to 9
Number of landings made at Chattanooga	553
Number of flat-boats	308
Pig-iron ....tons..	2,540
Iron ore ....tons..	17,677
Coal ....bushels..	1,001,872
Limestone ....tons..	10,542
Lumber, including poplar, pine, gum, oak, and walnut ....feet..	6,000,000
Grain ....bushels..	592,500
Cotton ....bales..	990

The estimate for improving this portion of the river was $225,000, of which have been appropriated $201,500 and expended $191,258.71.

Money statement.

July 1, 1879, amount available	$11,508 23	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$21,508 23
July 1, 1880, amount expended during fiscal year	11,266 94	
July 1, 1880, outstanding liabilities	241 29	
		11,508 23
July 1, 1880, amount available		10,000 00
Amount (estimated) required for completion of existing project		23,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		23,500 00

II.—BELOW CHATTANOOGA.

At the beginning of the fiscal year this work had reached a point where the vexatious delays of contractors had nearly ceased to hamper it, and it was, for the first time, making really satisfactory progress, with a fair prospect of being speedily completed. A heavy and unexpected reduction of the available funds, however, made it necessary to begin immediate retrenchment of the monthly expenditures, which were gradually reduced until the 1st of January, when the working force had been reduced about two-thirds and failing to get the special appropriation asked for to continue the work, the force was still further cut down, until on the 1st of May it had been reduced from 1,872 to 167 laborers and mechanics. It is unnecessary to dwell upon the serious injury to the work resulting from the disbandment of so large a force of skilled laborers, many of whom had come hundreds of miles to secure employment, and all had become more or less adapted to the special work before them. Nevertheless, the season was a favorable one, and a considerable amount of valuable work was accomplished, as will appear from the following details:

1.—ELK RIVER DIVISION.

The channel excavation opposite Brown's Island was continued until the 21st of October, when the small remaining force was removed to the quarries at and below Milton's Bluff, where it was employed in quarrying stone and completing and extending the retaining dam around Milton's Bluff, and eastward towards the lower end of Brown's Island.

11,246 cubic yards of rock were blasted and removed from channel.
4,516 cubic yards of rock quarried.
7,766 cubic yards of rock put in dams.
2,342 cubic yards of earth were stripped from the quarries and placed in the dams at such points as an earth filling was required.

The dams were substantially built, and have safely withstood the heavy floods of the last winter.

A suitable quarry for dimension stones for the locks was hunted up and opened so far as to demonstrate that the stone was of an excellent quality, both as to durability and ease of quarrying and cutting.

It is hoped that the present season's work will complete the channel excavation and so far extend the permanent dam that the temporary dam can be removed, and the first 5 miles of this shoal will become navigable, so that all our supplies may be boated down to the first lock below Milton's Bluff.

2.—BLUE WATER AND SHOAL CREEK DIVISIONS.

These divisions embrace all of the old canal around Big Muscle Shoals, which canal is being enlarged and rebuilt.

As explained in former reports, this old canal was built nearly fifty years ago by the State of Alabama, from the proceeds of the sale of 400,000 acres of land donated for that purpose by the general government. The canal was never completed according to the plans devised by the board of public works, and owing to certain radical defects of construction in the canal itself, as well as the neglect to extend the improvement around the entire obstruction, the canal was navigable only at high-water stages of the river, and soon fell into disuse and decay.

The new canal will be from 70 to 120 feet wide, with 6 feet of water, and will pass boats 60 feet wide, 300 feet long, and drawing 5 feet of water.

The following work was done during the fiscal year by hired labor:

8,717 cubic yards of stone quarried.
5,297 cubic yards of stone cut for locks, &c.
455.3 cubic yards of cut-stone masonry laid.
259 cubic yards of rock-face masonry laid.
1,997.7 cubic yards of rubble masonry laid.
38,639 cubic yards of earth embankment.
32,296 cubic yards of earth excavation.
5,078 cubic yards of solid rock excavation.
1,633 cubic yards of old masonry removed.
1,356 cubic yards of protection dams built.
3,614 cubic yards of riprap built.
4,670 cubic yards stripping, &c., at quarries.
192 cords of wood cut.

The contractor, Mr. S. N. Kimball, after obtaining a modification of his contract (May 12, 1879, as stated in last report) releasing him from building 2 of the 5 locks he had agreed to build, and again extending the time for the completion of the others, transferred his interest to other parties (in violation of the contract and law), and left the work. Mr. J. A. Henry, who claimed to have the work by subcontract, did some little work, but on the expiration of the extended contract time, there being no prospect that the work would be completed in any reasonable time, the contract was, on my recommendation, annulled by the Secretary of War.

The following work was done under this contract during the fiscal year:

17.2 cubic yards of cut-stone masonry laid.
110.2 cubic yards of rock-face masonry laid.
819.9 cubic yards of rubble masonry laid.
1,510.85 cubic yards of solid rock excavation.
1,857 cubic yards of hard-pan and loose rock excavation.
884½ cubic yards of earth excavation.
804 cubic yards of masonry of old locks removed.

3.—LITTLE MUSCLE SHOALS DIVISION.

The series of coffer-dams referred to in last report was extended nearly 1,800 feet and by this method the blasting and removal of rock from the channel at the head of the shoals was continued, with excellent results, until the 8th of December, when a sudden rise in the river put a stop to the season's work, just as the excavation in the area covered by the last coffer-dam was well under way.

The following quantities of work were performed during the year:

400 cubic yards of rock quarried.
1,799 cubic yards of rock put in dams.
1,864 cubic yards material put in coffer-dams.
14,446 cubic yards of solid rock excavated from channel.
417 cubic yards of bowlders removed from channel.

This work is not only done rapidly and cheaply, but thoroughly, the bottom of the excavated channel being made so smooth that it will not be likely to silt up, and there is no danger of a vessel striking projecting points, even if drawing too much water.

At this time, July 12, 1880, Mr. Willard, the assistant engineer in charge of this work, has just succeeded in repairing the last coffer-dam, which was considerably damaged by the winter's floods, and he is removing the rock at such a rate as to make it morally certain that the entire channel from Florence to Bainbridge will be open within six weeks, thus giving water transportation up to the lower end of the canal. This will greatly facilitate the work, as the canal has hitherto been accessible, at ordinary stages of the water, only by hauling supplies about 6 miles over a very bad road.

The present condition of the work may be summarized as follows:

1st. There has been completed about three-fourths of the entire canal trunk, including that required on Elk River division.

2d. Over one-half of the lock and aqueduct masonry is completed. The lock-gates, wickets, waste-weirs, and aqueduct trunk have not been commenced.

3d. The rock excavation and stone dams at Elk River are about half done, while those at Little Muscle Shoals will be so far completed as to admit the passage of boats before the 1st of September.

With reference to cost, the work will be two-thirds completed when the available funds are expended.

The entire expenditure properly chargeable to this part of the Muscle Shoals improvement has been $1,428,358, and from a carefully revised estimate, I am satisfied that with $700,000, in addition to the balance now on hand, the entire Muscle Shoals obstruction can be removed. This is far within the original estimate, and can only be realized by such annual appropriations as will enable the work to be prosecuted economically.

At Colbert Shoals, Duck River Shoals, and other points below Florence no work has been done, owing to the fact that the funds were so low and the condition of the work such as to prevent the organization of special parties for these works, or the detachment of any part of the force at Little Muscle Shoals.

Efforts were made, as yet without success, to obtain information from the officers of customs at the nearest port of delivery (Paducah); therefore, statistics bearing upon the commerce and navigation of the Lower Tennessee are meager. Undoubtedly there is considerable river trade. Three steamboats ply to and from Florence, Ala., during the winter and spring, and one the rest of the year. In 1879, 2,800 bales of

cotton were shipped to market by river from Florence, in addition to a heavy miscellaneous freight.

The Tennessee River is in the collection district of New Orleans.

The original cost of improving Tennessee River below Chattanooga was	$4,133,000 00
There has been appropriated	1,845,500 00
Expended, as previously reported	1,247,187 9[illegible]
Expended, fiscal year 1879–'80	273,073 [illegible]
Total expended	1,520,261 5[illegible]

Money statement.

July 1, 1879, amount available	$298,312 04	
Amount appropriated by act approved June 14, 1880	300,000 00	
		$598,312 [illegible]
July 1, 1880, amount expended during fiscal year	273,073 60	
July 1, 1880, outstanding liabilities	14,190 20	
		287,26[illegible]
July 1, 1880, amount available		311,04[illegible]
Amount (estimated) required for completion of existing project		2,287,5[illegible]
Amount that can be profitably expended in fiscal year ending June 30, 1882.		700,000 [illegible]

V 2.

IMPROVEMENT OF CUMBERLAND RIVER.

During the fiscal year work was continued at various obstructions below and above Nashville, when the stage of water and amount of available funds permitted.

I.—BELOW NASHVILLE.

Work on this section progressed till the middle of December; it was then discontinued by reason of high-water and inclement weather. Early in May work was resumed and continued without interruption.

The amount of work done during the fiscal year, and the present condition of the proposed improvements, as reported by Capt. L. C. Overman, United States Engineers, the officers in immediate charge of the work, are as follows:

1.—*Harpeth Shoals: seven-eighths finished.*

541 cubic yards of rock excavated from channel.
280 cubic yards of gravel excavated from channel.
5 snags removed from channel.
2,895 cubic yards of rock quarried.
2,895 cubic yards of dams built.

This obstruction, formed by a chain of five shoals, was, a few years ago, the most serious obstacle to low-water navigation below Nashville, but is now nearly removed.

2.—*Palmyra Island: three-fifths finished.*

7 snags removed from channel.
3,644 cubic yards of rock quarried.
2,510 cubic yards of dams built.

3.—*Dover Shoals: seven-eighths finished.*

5,165 cubic yards of gravel taken from channel.
9 snags taken from channel.
2,035 cubic yards of rock quarried.
5,823 cubic yards of dams built.

At certain points the banks were protected by riprap, built of stone picked up along shore.

4.—*Ingram Shoals: five-eighths finished.*

30 cubic yards of rock removed from channel.
90 cubic yards of gravel removed from channel.
38 snags removed from channel.
4,957 cubic yards of rock quarried.
7,939 cubic yards of dams built.

5.—*Race Track Shoals: three-eighths finished.*

73 snags removed from channel.
2,974 cubic yards of rock quarried.

6.—*Little River Shoals: five-eighths finished.*

3 snags removed from channel.
3,335 cubic yards of rock quarried.
4,290 cubic yards of dams built.

A derrick-boat, with a small working force, was employed for a few days in June removing obstructions from the channel in the vicinity of Canton and Race Track Reefs, taking out 56 snags, 88 cubic yards of rock, and cutting down 34 overhanging trees.

The appropriation of $20,000, act of 1880, and the estimate herewith for 1882, are needed for the continuance or completion of the improvements above named.

An increase of about 4 inches in the minimum depth of water has been gained at extreme low-water below Nashville by these unfinished improvements.

The original estimate of cost of improving Cumberland River below Nashville was $248,821.

Total amount appropriated	$205,000 00
Total amount expended	178,270 81

Money statement.

July 1, 1879, amount available	$42,255 16	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$62,255 16
July 1, 1880, amount expended during fiscal year	35,525 97	
July 1, 1880, outstanding liabilities	2,768 08	
		38,294 05
July 1, 1880, amount available		23,961 11
Amount (estimated) required for completion of existing project		43,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		43,821 00

II.—ABOVE NASHVILLE.

SECTION NASHVILLE TO KENTUCKY LINE.

Work on this section was continued from July 1 to March 1, when active operations were suspended in consequence of floods.

On the 15th of June work was resumed at Simpson's Island Shoals, by clearing the channel of the heavy drift accumulated during the winter.

The amount of work done, and the present condition of the proposed improvements, as reported by Captain Overman, are as follows:

1.—*Bartlett's Bar: three-fourths finished.*

256 cubic yards gravel taken from channel.
150 cubic yards dams built.

2.—*Sand Shoals: seven-tenths finished.*

701 cubic yards rock take from channel.
305 cubic yards gravel taken from channel.
4 snags taken from channel.
1,007 cubic yards dams built.

3.—*Indian Creek Shoals: seven-tenths finished.*

284 cubic yards rock taken from channel.
905 cubic yards gravel taken from channel.
4 snags taken from channel.
1,252 cubic yards rock quarried.
1,376 cubic yards dams built.

4.—*Holliman's Island Shoals: seven-eighths finished.*

695 cubic yards gravel taken from channel.
2 snags taken from channel.
1,500 cubic yards of rock quarried.
1,608 cubic yards dams built.

5.—*Cub Creek Shoals: seven-eighths finished.*

2,565 cubic yards gravel taken from channel.
15 snags taken from channel.
470 cubic yards rock quarried.
1,925 cubic yards dams built.

6.—*Simpson's Island Shoals: four-fifths finished.*

2,256 cubic yards gravel taken from channel.
74 snags taken from channel.
1,101 cubic yards rock quarried.
1,032 cubic yards dams built.

A derrick-boat, employed a short time on this section, removed from the channel at isolated points 593 snags, logs, and overhanging trees.

The appropriation of 1880, for this section, together with that asked for herein, will be applied to continuing the work at the above-named shoals, and beginning the improvement of Goose Creek Shoals, Donaldson's Horse Ford, snagging and dredging the channel, &c., where most needed.

Money statement.

July 1, 1879, amount available	$21,664 07	
Amount appropriated by act approved June 14, 1880	15,000 00	
		$36,6[illegible]4 [illegible]
July 1, 1880, amount expended during fiscal year	17,523 03	
July 1, 1880, outstanding liabilities	467 12	
		17,990 15
July 1, 1880, amount available		18,67[illegible] 9[illegible]
Amount (estimated) required for completion of existing project		54,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		54,155 00

SECTION KENTUCKY LINE TO SMITH'S SHOALS.

The only work done upon this section during the fiscal year was by means of a snag-boat, which worked through the entire section, and removed 50 cubic yards of bowlders, and 1,196 snags, logs, and overhanging trees.

This section extends to the head of steamboat navigation. The funds now available, together with the estimate herein, should be applied to the improving of Wolf Creek Shoals and Wild Goose Shoals, and the snagging and dredging of the channel. The former is three-fourths and the latter is one-fourth finished.

Money statement.

July 1, 1879, amount available	$6,003 49	
Amount appropriated by act approved June 14, 1880	10,000 00	
		$16,003 49
July 1, 1880, amount expended during fiscal year		1,774 50
July 1, 1880, amount available		14,228 99
Amount (estimated) required for completion of existing project		57,609 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		57,609 00

SECTION SMITH'S SHOALS, THREE-FOURTHS FINISHED.

Work was carried on during the fiscal year on this section for about four and a half months, from July to November, when the work was stopped for want of funds.

The Smith's Shoals obstructions, especially that part known as Long Shoals, has been found more formidable than was anticipated, and may require some change of plan to overcome the difficulties encountered.

While at low-water a person may walk about these shoals dry shod, it is found that during the flood stages the stream becomes a torrent of such force as to pick up large stones and roll them along as a small stream does pebbles. The dams built to narrow the channel have, from this cause, been seriously damaged, and it is found that great care must be taken in locating the dams to avoid dangerous waves being formed, which swamp boats and neutralize the benefit of the additional depth of water gained by them. All the work done in smoothing the bottom of the channel is without question advantageous, and the dams can doubtless be made so by certain modifications suggested by past experience. A careful examination of the dams is now being made, with a view to ascertaining the exact cause and extent of damage done by last winter's flood, and the best means of overcoming the difficulties encountered.

At the four shoals forming this obstruction, the following work was done during the fiscal year:

10,522 cubic yards solid rock excavated from channel.
5,130 cubic yards loose rock and gravel excavated from channel.
4,403 cubic yards rock quarried.
11,993 cubic yards dams built.
610 cubic yards masonry in cement, to form a false bottom to lengthen slope.
492 cubic yards concrete (surfacing).

Money statement.

July 1, 1879, amount available	$22,443 03	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$42,443 03
July 1, 1880, amount expended during fiscal year	22,096 38	
July 1, 1880, outstanding liabilities	31 00	
		22,127 38
July 1, 1880, amount available		20,315 65

Amount (estimated) required for completion of existing project	$10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	10,000 00

SECTION SMITH'S SHOALS TO THE FALLS OF THE CUMBERLAND.

No appropriation has been made for this section since act of June 18, 1878. The small balance available has been expended in removing 246 cubic yards of loose rock, &c., from the channel. The entire work on this section has been done below the mouth of Laurel River, and confined to the removal of the worst obstructions.

Money statement.

July 1, 1879, amount available	$373 11
July 1, 1880, amount expended during fiscal year	373 11

The dams and rock excavation are of a permanent nature, but it will require a small annual expenditure beyond the estimates for repairs and for removing snags and excavation of gravel, &c., from bars.

Capt. L. C. Overman reports in regard to statistics of commerce and navigation as follows:

Accurate statistics regarding the commerce of the Cumberland River are difficult to obtain, being meager and irregular.

There are in all about sixteen steamers engaged in commerce on the Cumberland River, averaging about 300 tons each. These steamers run between Nashville, Tenn., and the various cities and towns on the Cumberland, Tennessee, Mississippi, and Ohio Rivers and their tributaries. During high-water the smaller of these steamers also ascend the Caney Fork and Obey's River branches of the Cumberland River.

The total of products brought to and from Nashville annually is about as follows: Tobacco, $1,500,000; cotton, $.00,000; iron trade, $1,600,000; corn, $1,250,000; lumber, $800,000; coal, $100,000; wheat, $60,000; oats, $70,000; salt, $75,000; sundries, $500,000.

The entire valley of the Cumberland River will be largely benefited by the improvement of the river, as railroads cross the river at but few points, and as a rule are too distant from the immediate lands along the river to render transportation cheap. The coal of the upper river and the iron of the lower river depend almost entirely upon the river for a means of getting to market, and with the improvement of the river a corresponding improvement in the trade in these articles will follow. The lumber trade is increasing rapidly each year.

This work is in the collection district of New Orleans.

The estimate of cost of improving the Cumberland River, above Nashville, was $283,764.

The whole amount appropriated for and expended on the sections specified is as follows:

	Appropriated.	Expended.
Nashville to Kentucky line	$68,000 00	$48, [illegible]
Kentucky line to Smith's Shoals	34,000 00	19, [illegible]
Smith's Shoals	90,000 00	69, [illegible]
Smith's Shoals to Falls of the Cumberland	4,000 00	4, [illegible]
Total	196,000 00	142, [illegible]

V 3.

IMPROVEMENT OF THE HIAWASSEE RIVER, TENNESSEE.

There being no funds available for this work at the beginning of the fiscal year, active operations were not resumed until August, when the appropriation of March 3, 1879, was made available.

Operations were directed towards the completion of the improvements at Matthew's Shoals, Magill's Island, and Canefield Reef.

The appropriation being a small one, only $3,000, it was so nearly exhausted that it became necessary to suspend operations in October, when the boats and tools were laid up under charge of watchmen, and so remained at the end of the fiscal year.

The following quantities of work were done during the season:

Earth stripping from quarries	213 cubic yards.
Rock quarried	581 cubic yards.
Rock blasted from channel	98 cubic yards.
Rock placed in dams and riprap	656 cubic yards.
Gravel excavated from channel	59 cubic yards.
Brush placed in dams	42 cords.

The work has been carried on by hired labor.

The improvement of this river was begun in 1877, and consists in securing additional depth of channel at shoal places by excavation and by narrowing the water-way.

The original examination and project for this improvement was made in 1874, and the estimate of cost then made was $20,000.

As stated in my last annual report, this amount will not be sufficient by at least $10,000 to complete the work as far as Savannah Ford, for the reasons that the work is being done in the most thorough and substantial manner, and that some of the rock excavation proves to be exceptionally difficult.

The work is now essentially completed as far up as Charleston, and the present appropriation (1880) and that asked for in the estimate herewith are needed for extending the improvement above Charleston towards Savannah Ford.

The navigation of this river has been greatly improved by the work already done, and the amount of commerce has been correspondingly increased.

Estimates for improving Hiawassee River	$30,000 00
Amount appropriated	26,000 00
Amount expended	22,966 80

Money statement.

July 1, 1879, amount available	$3,035 92	
Amount appropriated by act approved June 14, 1880	3,000 00	
		$6,035 92
July 1, 1880, amount expended during fiscal year	3,002 72	
July 1, 1880, outstanding liabilities	33 20	
		3,035 92
July 1, 1880, amount available		3,000 00
Amount (estimated) required for completion of existing project		4,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		4,000 00

V 4.

IMPROVEMENT OF FRENCH BROAD RIVER, TENNESSEE.

An appropriation of $10,000 was made for improving this river "between Knoxville and the mouth of Big Creek," act of June 14, 1880 (Knoxville is, strictly speaking, 4½ miles below the mouth of the French Broad), but the funds not being available until after the 1st of July, no work was done during the fiscal year.

The money now (July 20) being available, it is proposed to begin work

at once by organizing a force and removing the more troublesome snags, bowlders, and other obstructions along the river from its mouth to Leadvale, or as much of it as can be done during the balance of the low-water season.

The amount herein estimated for will be needed for continuing these operations and blasting rock from the channel, building wing-dams, &c., to secure a permanent increase of depth to the channel.

No statistics as to the amount of benefit to commerce to be expected from this improvement have been procured, other than those given in the reports of the original examinations of this river. (See reports of Chief of Engineers, 1871, pp. 491 to 494; 1876, pp. 718 to 722.)

The French Broad River, in Tennessee, extends from Paint Rock (State line) to its mouth, 4½ miles above Knoxville.

From Paint Rock to Leadvale, a distance of 31 miles, no estimate of cost of improvement has been made, for the reasons given by Maj. Walter McFarland. (See Report Chief of Engineers, 1876, p. 719.)

No estimate has been submitted for improving the river between Leadvale and Dandridge, distance about 20 miles, having nine principal obstructions.

Original estimate of cost from Dandridge to mouth of river, $150,000. (See Report of Chief of Engineers, 1871, p. 494.) Amount appropriated, $10,000.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	10,000 00

V 5.

IMPROVEMENT OF CLINCH RIVER, TENNESSEE.

An appropriation of $10,000 was made, act of June 14, 1880, for improving this river, of which sum, $6,000 shall be expended above and $4,000 below Haynes, but the funds not being available until after the 1st July, no work was done during the fiscal year.

The money now (July 20) being available, it is proposed to begin work at once by organizing a force and removing the more troublesome snags, bowlders, and other obstructions along the river, between the head of navigation and Kingston, or as much of it as can be done during the balance of the low-water season.

The amount herein estimated for will be needed for continuing these operations, and blasting rock from the channel, building wing-dams, &c. to secure a permanent increase of depth to the channel.

For a detailed report on the obstructions in this river, and an estimate of the cost of their removal, and the benefits to be expected therefrom (see report of Chief of Engineers, 1876, pp. 741 to 745).

The original estimate for improving the Clinch River in Tennessee, from the boundary line between Virginia and Tennessee, distance 230 miles, was $26,400, amount appropriated $10,000.

Money statement.

Amount appropriated by act approved June 14, 1880	$10,000 00
July 1, 1880, amount available	10,000 00
Amount (estimated) required for completion of existing project	16,400 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	10,000 00

V 6.

IMPROVEMENT OF DUCK RIVER, TENNESSEE.

An appropriation of $7,000 was made for improving this river, act of June 14, 1880, but the funds not being available until after the 1st of July, no work was done during the fiscal year.

The money now (July 20) being available, it is proposed to begin work at once by organizing a force and removing the more troublesome snags, bowlders, and other obstructions along the river below Centerville, or as much of it as can be done during the balance of the low-water season.

The amount herein estimated for will be needed for continuing these operations, and blasting rock from the channel, building wing-dams, &c., to secure a permanent increase of depth to the channel.

Original estimate of cost of improving Duck River, Tennessee, was $35,118; amount appropriated $7,000.

For a detailed report on the obstructions in this river, and an estimate of the cost of their removal, and the benefits to be expected therefrom (see report of Chief of Engineers, 1880).

Money statement.

Amount appropriated by act approved June 14, 1880	$7,000 00
July 1, 1880, amount available	7,000 00
Amount (estimated) required for completion of existing project	28,118 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	10,000 00

EXAMINATION OF DUCK RIVER FROM ITS MOUTH TO CENTERVILLE, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., November 22, 1879.

GENERAL: I have the honor to submit herewith a report on an examination of Duck River, made in compliance with your letter of instruction of the 25th of April, 1879.

Assistant Engineer D. L. Sublett was detailed to make the examination, and his report, which is appended hereto, shows that an expenditure of $35,000 will make this stream navigable for half the year, which will answer all purposes of navigation. At extreme low stages there s not enough water to fill a channel of sufficient size to float steamers, and low-water navigation cannot therefore be provided for without esorting to locks and dams, at a cost far in excess of what the needs of ommerce would justify.

The obstructions generally consist of rock reefs, gravel bars, and snags, f the same general character as those in most of the streams in this egion, and the proposed improvements consist of rock and gravel excavation, building wing-dams, and removing snags and overhanging rees. The improvement once completed will be comparatively permaent, and will require but little expense in the way of repairs for a numer of years.

In the year 1846 the State of Tennessee chartered a company styled he "Duck River Slackwater Navigation Company," giving this comany "the exclusive right for fifty years from January 15, 1846, to

navigate Duck River with steamboats, barges, and keels." Under this charter work was commenced below Columbia, Tenn., and one or more locks were partially completed. As the rights of this company, if still in existence, might be brought in question, in case the government should undertake to improve the river, I addressed a letter to Governor Marks, asking information on the subject, and in reply received a letter forwarded from Hon. W. C. Whitthorne, stating that—

The Duck River Slackwater Navigation Company, in a suit against the company by a part of its stockholders, was perpetually enjoined from the prosecution of its work, &c., in December, 1853, by the chancery court at Columbia, Tenn. Since then no other company has attempted to revive the enterprise in any shape.

The terms of the charter required that the work should be completed within twenty years, which was afterwards extended to twenty-five years. The charter, therefore, expired by limitation in 1871, unless it has been renewed at some time since 1848. I cannot learn certainly whether this has been done, but presume it has not; and it is not probable that any trouble can arise from the aforesaid company; but if the State of Tennessee claims the right to grant the exclusive privilege of navigating Duck River to private parties, it would seem proper that the United States should require some assurance that this right will not be exercised before expending money for improving that river. I would therefore suggest that, if an appropriation is made, it be "provided that before any of this money be expended the State of Tennessee shall relinquish all right and control over the navigation of said Duck River below Centerville, Tenn., and shall guarantee that no claim shall be brought against the United States in consequence of any franchise granted by said State."

The maps pertaining to this examination, which consist of one general map of the river from Centerville to the Tennessee River and thirty-eight detailed sketches of the principal obstructions, showing the locations of the proposed improvements, will be forwarded as soon as they are copied.

This river is in the collection district of New Orleans, and the nearest port of delivery, by water, is Paducah, Ky.

The probable advantages to be derived by the improvement are set forth in Mr. Sublett's report herewith.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. D. L. SUBLETT, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *October* 11, 1872.

MAJOR: I would respectfully present herewith my report on the examination of Duck River from Centerville, Hickman County, Tennessee, to its confluence with the Tennessee River, about 14½ miles above Johnsonville.

In obedience to orders received August 27, I left Elk River Shoals, Alabama, on the 28th, and proceeded to Columbia, Tenn., arriving on the 29th. This is the nearest point by rail to Centerville, distance about 33 miles by land and 55 by Duck River. Soon after reaching Columbia, a heavy rain began and continued for two days. Learning that no boats c uld be obtained at Centerville, two were hired at Columbia. I proceeded down Duck River to Centerville, arriving there on the evening of the [illegible] September, the river being about 8 feet above low-water. On Monday, the 9th, the river having fallen to 2 feet above low-water, operations were begun. Having procured here a pilot familiar with the river, the examination was continued with

interruption to Tennessee River, and was completed on the 22d, when, in accordance with instructions, I proceeded to Johnsonville, and thence by rail to Chattanooga.

The following are the results of the examination: Centerville, the highest point to which steamboats have successfully ascended, is situated near the western edge of the blue grass section of Middle Tennessee, and is by actual measurement made by the engineer of the Duck River Slackwater Navigation Company, 67 miles from the Tennessee River. In the winter of 1877-'78, the steamer Shields made two successful trips to Centerville, and also the steamer Mary Clese made a trip about 1875. Both steamers, however, were damaged by overhanging trees and snags, and further attempts were abandoned. Though successful in a pecuniary point of view, the risk was considered too great. Duck River was regularly navigated a few years back by flat-boats carrying 200 tons of pig-iron. When the Ætna Furnace was operated, about 2,000 tons of pig-iron were annually shipped, until the suspension of operations by the depression in the iron trade. Steamboats have frequently run as high as the Hackle Shoals about 25 miles from the mouth. This is the most formidable obstruction on the river. The steamer Shields was 125 feet long, 22 feet wide, and drew 18 inches light, and had a capacity of 200 tons. I was unable to obtain the dimensions of the Mary Clese. Private efforts are now being made to build a boat especially for the Duck River trade by some of the citizens.

The character of the obstructions found on Duck River consists almost entirely of short gravel bars or ridges, with intervening pools of deep water from a quarter of a mile to 4 miles long (the water in the pools being generally from 4 to 10 feet deep). Overhanging trees, snags, logs, and trees lodged in the channel, which latter obstructing the river, cause a division of the water. The removal of these latter obstructions and confining the river to a single channel by means of riprap dams will, it is believed, procure from 2½ to 3½ feet of water during the boating season. Few of the bars have less than 1 foot of water at extreme low-water.

From the most reliable information, gathered by repeated inquiries, I learned that ordinary winter tide was from 2 to 3 feet above low-water, which would give with the improvements contemplated ample water for 4 to 6 months' navigation. There is but one rock shoal, namely, "Blue Rock," and this presents no serious obstacles to navigation. Estimates for 4 to 6 months' navigation were made, the volume of water not being sufficient for low-water navigation without locks and dams. From Centerville to near its mouth Duck River is uniformly bounded by a rock bluff on one side and rich alluvial bottoms on the other, alternating and changing, however, at each bend of the river. The banks are from 10 to 25 feet high, and on the bluff side from 100 to 200 feet high. There is no instance where extensive bottoms or bluffs occur on both sides at the same time. The bluffs consist of subcarboniferous limestone and thick strata of a dark silicious rock, which is finely displayed at the "Grandfathers and Grandmothers" buildings in cliffs from 150 to 200 feet high. The prevailing rock in Humphreys County is sandstone, susceptible of high polish. The banks are of a light alluvial nature, with a substratum of gravel near the water's edge about 2 feet thick; the bottoms are broad, exceedingly fertile, and highly cultivated. The valleys of Pine River, Beaver Dam, Little Piney, Sugar, Hurricane, and Blue creeks also contain large areas of magnificent bottoms, which readily command from $25 to $50 per acre. Big Bottom, which extends some 15 or 20 miles above the mouth of Duck River, contains about 17,000 acres. The time allowed being brief, surveys were only made at points requiring improvement, the distance being measured by a transit with stadia wires, and fall ascertained with the same instrument. The distances between localities are closely approximate, and were corrected from time to time by mile stations established by Mr. Drury, the engineer who surveyed the river for the "Duck River Slackwater Navigation Company." The fall from Columbia, as ascertained by Mr. Drury, was 213¼ feet and the distance 125 miles, or 1.70 feet per mile. High-water on the Tennessee River at Fowler's Landing is 363 feet above tide or 43.31 feet above water surface on September 22, and high-water at Columbia is 571 feet above tide; this would give for the fall from Columbia 208 feet. The fall is very evenly distributed, the greatest being at Johnson Shoal, which is 5.29 feet in 5,580 feet, taken when the water was seven-tenths above low-water. High-water was ascertained to be at Centerville 28 feet at the bridge above low-water; at Nick's Ferry, where the river was narrow, approximately 32 feet. At Haney's Point it was accurately ascertained to be 34.20 feet, being back water from the Tennessee River, 5 miles distant. At Fowler's Landing, on the Tennessee River, it was found to be 43.31 feet above water surface September 22, or approximately 45 feet above low-water. The Tennessee backs water to Hurricane Creek, on Duck River, about 19 miles. A short distance below Centerville, near Pace's Island, at a point most favorable for the purpose, cross-sections were taken every 10 feet, and the volume of water ascertained to be at approximate mean velocity 1,270 cubic feet per second, the river being 2 feet above low-water; cross-sections and velocity were also taken below the mouth of Pine River and Beaver Dam Creek, and volume of water was found to be at mean velocity 1,187 cubic feet per second, the river being 1 foot above low-water. A tabulated statement is submitted

herewith, showing the nature of the improvement required at each obstruction, with the length and fall, &c. The following is the estimated cost of improving the river:

2,700 cubic yards riprap for banks, at $1.50		**$4,05[illegible]**
7,034 cubic yards riprap dam, at $2		**14,06[illegible]**
436 snags and roots, at $3		**1,3[illegible]**
162 trees in channel, at $6		**9[illegible]**
127 cubic yards loose rock excavation, at $1		**12[illegible]**
50 cubic yards solid rock excavation, at $4		**20[illegible]**
3,400 cubic yards earth excavation, at 20 cents		**68[illegible]**
10,320 cubic yards gravel excavation,	**5,720 cubic yards, at $1**	**5,72[illegible]**
	4,600 cubic yards, at 40 cents	**1,84[illegible]**
300 (about) overhanging trees, at $1		**30[illegible]**
20 per cent. for engineering and contingencies		**5,8[illegible]**
Total		**35,1[illegible]**

The most effective means of closing the chutes has been demonstrated to be by me[illegible] in "riprap," on brush, with a very broad base and sufficiently high to confine all th[e] water to a single channel at ordinary winter tide. One rise is generally sufficie[nt to] make the dam tight with leaves, sand, and gravel brought down by the river. T[he] leaning trees should be cut in winter when the sap is down, as the stumps then thr[ow] out sprouts, which afford an excellent protection to the loose soil; if cut in the s[um]mer, the stumps die and leave no protection to the banks.

In 1848 a charter was granted to the Duck River Slackwater Navigation to impr[ove] the river to Columbia by means of locks and dams. One lock and dam was built [at] Columbia, and some open channel improvements made below Centerville, but ow[ing] to some suits instigated, as I learned, for damages, and a lack of confidence by [the] stockholders in those having control, the enterprise was abandoned.

POPULATION, RESOURCES, ETC.

The population of Hickman and Humphreys counties in 1870 aggregated 20,[illegible] great portion of which reside in the valleys of Duck and Buffalo rivers and their t[rib]utaries; they are remarkable for their industrious, economical, and law-abiding ha[b]its; for two years there was no inmate in the jail of Hickman County, and the c[ourt] docket is so small that lawyers find it difficult to make a living. The following s[ta]tistics are from the report of the commission of agriculture for the State of Tenn[essee] for 1872:

Hickman County.

Total assessed acreage, 359,551; value	$1,4[illegible]
Total value of taxable property	1,4[illegible]

Humphreys County.

Total assessed acreage, 322,133; value	$1,25[illegible]
Town lots	[illegible]
Value assessed property	1,48[illegible]

Agricultural productions.

8,000 acres peanuts	bushels	[illegible]
9,956 acres corn	do	[illegible]
5,168 acres oats	do	6[illegible]
876 acres wheat	do	131[illegible]
120 acres rye	do	1[illegible]
144 acres Irish potatoes	do	[illegible]
180 acres sweet potatoes	do	1[illegible]
279 acres apples	do	[illegible]
216 acres peaches	do	21[illegible]
180 acres sorghum	gallons	[illegible]
2,829 acres grasses.		

These statistics are about the same for Hickman County, and the productions [are] principally raised on Duck River and its tributaries. The chief market for the pr[oduce] of Hickman County is Nashville, by means of wagons, and is distant some sixty mi[les] over a common dirt road and exceedingly rough country. Still, it is not uncomm[on] to see from sixty-five to seventy-five wagons on the road to Nashville, and the sa[me] may be seen in Humphreys County, the produce being hauled to the Tennessee Riv[er]. The great staple in these counties is peanuts, now worth in market $1.15 per bush[el], and in 1872 there were produced in these counties 475,000 bushels.

Big Bottom alone shipped 150,000 bushels of corn, besides many hogs and large quantities of hay. The average expense of hauling peanuts to market is 23 cents per bushel, and grain cannot be raised for market, as the cost of transportation eats up the profits. The great future wealth of these counties, however, is the immense iron-ore deposits, which lie along the hills and valleys bordering Duck River. The Ætna property, situated on Beaver Dam Creek, alone has enough ore to supply all the furnaces that could be conveniently built upon it. Timber for charcoal purposes is equally abundant. Some consider the deposits in these counties equal to the Iron Mountain of Missouri; the ore yields 44 per cent. from the furnace. This property, the finest of the kind in the State of Tennessee, now lies idle for the want of cheap transportation.

TIMBER.

Timber is everywhere abundant and of the finest quality; it consists of all the different varieties of oak, white hickory, ash, poplar, walnut, cherry, chestnut, black locust, beech, and sycamore, and on the hills the long-leaf pine abounds, as does also the cedar and other varieties. Considerable cotton is raised, which finds a market at Pinewood, where there is a cotton factory. There is also on Hurricane Creek a woolen factory, and near Buffalo an ax-handle factory, the hickory used being superior for this kind of manufacturing. Accompanying this report is an index-map of the river from Centreville to its mouth.

I am, major, very respectfully,

D. L. SUBLETT,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

Name of locality.	Distance from Centerville.	Length of survey.	Least depth in channel at low-water.	Fall.	Nature of obstruction.	Improvement suggested.	Approximate quantities.
	Miles.	*Feet.*	*Feet.*	*Feet.*			*Cu. yds.*
Centerville	00						
Indian Creek	.50			2.50	1 snag; 6 overhanging trees		
Ship Island Shoal	3.00	655	1.00	0.65	Gravel bar; division of channel; 6 overhanging trees	Riprap dam	150
Water's Bar	3.50	550	.90	0.60	3 overhanging trees; gravel reef, dry	Gravel excavation	200
Pace's Island	4.00				1 snag; 5 overhanging trees		
Metal Landing	4.90	518	.90	0.72	Caving bank; 1 snag; 5 overhanging trees; 1 rock	Riprap for banks Solid rock	100 10
McClanahan's	6.65	550	.80	0.92	2 snags; 10 overhanging trees; gravel reef or bar	Gravel excavation	550
Shouse Island	7.15	543	.80	0.68	Divided channel; 1 snag; 3 overhanging trees	Riprap dam	45
Shouse, 2d bar	7.40	345	1.10	0.42	Divided channel; 3 overhanging trees	......do	100
Shouse, 3d bar	7.65				Divided channel; 7 overhanging trees	......do	266
Huddleston's Ford	7.90	965	.80	0.70	Broad and shallow	Jetty dam	106
Head of Log Shoal	10.90				3 snags; 3 overhanging trees		
Foot of Log Shoal	11.60				7 snags; very short turn		
Briggs's Island	12.35	946	.90	1.50	Divided channel; 7 snags; 5 overhanging trees	Riprap dam	180
Easten's Shoal	12.85	1,900	1.00	2.97	Divided channel; shallow caving banks; 12 snags; 12 overhanging trees.	......do Riprap for banks Gravel excavation	330 400 50
Trace's Shoal	16.10	896	1.00	1.20	Divided channel; 18 snags; 10 overhanging trees	Riprap dam	125
Piney River Ford	17.50	850	1.10	2.00	Fish dam; five snags	Loose rock excavation	15
Nick's Ferry	17.90				No improvement		
Scott's Ford	19.90	775	.95	0.82	Divided channel; narrow place; 6 snags; 8 overhanging trees	Riprap dam Gravel excavation (wet)	255 140
Suck Island	21.15	600	1.00	0.77	Divided channel; narrow place; 4 snags	Riprap dam Gravel excavation	220 500
Lovett's Shoal	23.40	700	1.20	0.73	1 rock in channel; 20 snags; 8 overhanging trees	Solid rock excavation	20
Little Piney	24.65	340	1.30	0.62	Fish trap; 2 overhanging trees	Loose rock excavation	10
Beaver Dam Creek	25.65	575	.70	1.50	Broad and shallow; caving banks; 2 snags; 2 overhanging trees	Riprap banks Gravel excavation (wet) Solid rock excavation	300 550 10
Blue Rock Shoal	26.40	662	.90	2.15	1 rock in channel; 5 overhanging trees	......do	10
Five Islands Shoal	28.90	1,700	.40	3.10	Divided channel and crooked caving banks; 50 snags; 10 overhanging trees.	Riprap for banks Riprap dam Gravel excavation Earth excavation	600 800 1,660 3,400
Burchard's Eddy	29.65				Rock and brush dam; 8 snags	Loose rock	75
Gullett Chute	30.15	1,138	1.40	2.09	Short bend; 10 snags; divided channel	Riprap for banks	200
Wolf Creek	33.40				Sluice right; 5 snags	Riprap dam	50
Long Shoal	34.50		40		6 snags; gravel bar	Gravel excavation (wet)	150
Bickerstaff Eddy	34.75				1 snag		
Brown's Bend	[illegible]				Caving banks; 2 snags	Riprap for banks	200

[illegible]	[illegible]				[illegible] channel		
					No improvement	Riprap dam	200
Wilkin's Shoal	38.75	700	.85	1.20	Divided channel; 8 snags; 42 overhanging trees	Riprap dam	166
Wilkins's Shoal (lower end)	39.00	865	.30	1.25	Gravel bar at lower end	Gravel excavation (wet)	470
Sugar Creek	39.65				8 snags; 6 overhanging trees; loose rock	Loose rock	2
Grandfather's Building	40.65				2 snags		
Prewett's Shoal	43.90	810	1.00	1.42	Divided channel, caving banks and low; 15 snags; 20 overhanging trees.	Riprap dam Riprap for banks Gravel excavation (wet)	80 750 500
Tumbling Creek	45.00	1,800	.50	2.55	Divided channel; gravel bar; 10 snags	Riprap dam Gravel excavation (dry)	222 500
Hackle Shoal	46.50	6,639	.30	4.60	Divided channel; short bends; weak banks; 100 overhanging trees.	Riprap dam Gravel excavation (dry)	2,009 4,100
O'Donnelly's	49.50				Small chute right	Riprap dam	50
Cow Ford	50.00				Divided channel	do	100
Hurricane Creek	51.00	3,760	.70	3.29	Divided channel; crooked channel; 26 snags; 15 overhanging trees.	do Gravel excavation (wet)	290 950
Buffalo River	52.50				8 snags		
Johnson's Shoal	55.00	5,580	1.00	5.29	Divided channel; caving banks; short bends; 100 snags	Riprap dam Riprap banks	600 100
Wagoner's Shoal	61.00				27 snags; 5 overhanging trees		
Hurricane Rock	62.00				Fallen rock	Loose rock excavation	20
Haney Point	63.50			10.80 ft. fall.	Loose rock	do	5
Beven's Bar	65.00	680	1.00	0.7	Divided channel; 3 overhanging trees		
Dudley's Bend	65.50		1.00		From Hurricane Rock to Tennessee River about 228 snags and trees lodged.		
Tennessee River	68.50		1.50				
Total fall				122.05			

V 7.

IMPROVEMENT OF OBEY'S RIVER, TENNESSEE.

An appropriation of $4,000 was made for improving the Obed's River, Tennessee, June 14, 1880. The appropriation is understood to be for Obey's River, and based upon an examination of that river, a tributary of the Cumberland, the report of which examination was made February 6, 1879. (See Report of Chief of Engineers, Appendix T.) The spelling was corrected by amendment in the Senate from *Obed's* to *Obey's*, but the printed copies of the act still retain the apparent error. There is an *Obed's* River, rising near the source of *Obey's* River, but it is a much smaller stream, and runs into the Emory River. No examination of it has ever been made.

The funds not being available until after the 1st July, no work was done during the fiscal year.

The money now (July 20) being available, it is proposed to begin work at once by organizing a force and removing the more troublesome snags, bowlders, and other obstructions along the river, or as much of it as can be done during the balance of the low-water season.

The amount herein estimated for will be needed for continuing these operations, and blasting rock from the channel, building wing-dams, &c., to secure a permanent increase of depth to the channel.

For a detailed report on the obstructions in this river, and an estimate of the cost of their removal, and the benefits to be expected therefrom, see Report of Chief of Engineers, 1879, p. 1277.

Original estimate for improving Obey's River, Tennessee, was $11,869; amount appropriated, $4,000.

Money statement.

Amount appropriated by act approved June 14, 1880	$4,000
July 1, 1880, amount available	4,000
Amount (estimated) required for completion of existing project	7,869
Amount that can be profitably expended in fiscal year ending June 30, 1882	7,869

V 8.

IMPROVEMENT OF CANEY FORK RIVER, TENNESSEE.

An appropriation of $6,000 was made for improving this river, act of June 14, 1880, but the funds not being available until after the 1st of July, no work was done during the fiscal year.

The money now (July 20) being available, it is proposed to begin work at once by organizing a force and removing the more troublesome snags, bowlders, and other obstructions along the river, or as much of it as can be done during the balance of the low-water season.

The amount herein estimated for will be needed for continuing these operations, and blasting rock from the channel, building wing-dams, &c., to secure a permanent increase of depth to the channel.

Original estimate of cost of improving Caney Fork River was $30,228; amount appropriated, $6,000.

For a detailed report on the obstructions in this river, and an estimate of the cost of their removal, and the benefits to be expected therefrom, see Report of Chief of Engineers, 1879, p. 1275.

Money statement.

Amount appropriated by act approved June 14, 1880	$6,000 00
July 1, 1880, amount available	6,000 00
Amount (estimated) required for completion of existing project	24,228 00
Amount that can be profitably expended in fiscal year ending June 30, 1882	12,000 00

V 9.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

The appropriations for this river are made applicable to that portion lying between Rome, and the Selma, Rome and Dalton Railroad Bridge.

From Rome to Greensport the river has been put in a tolerably good navigable condition at all seasons, by the excavation of reefs, building of wing-dams, &c., as explained in former reports; and efforts are now directed to the removal of the Ten Island Shoals obstruction, which, including Whistenant's Mill Shoals, requires three locks and several thousand feet of dams. The work at this point has been carried on by hired labor continuously during the fiscal year, and is now making good progress.

Three quarries have been opened, and a large quantity of riprap and dimension stones have been quarried, and a sufficient quantity of the latter has been cut to justify the beginning of the laying of masonry.

The foundation of a dam across the river 1,100 feet long has been laid, and two lock-pits have been excavated, besides considerable preparatory work in the way of laying temporary railroad track, building cars, derricks, &c.

The following is a statement of the work done during the fiscal year:

1,039 cubic yards of solid rock excavated from channel.
6,124 cubic yards of rock quarried.
3,714 cubic yards of rock put in dams.
5,000 feet of timber framed in dams.
1 coffer-dam (300 by 60 by 8 feet) built.
12,756 cubic yards of earth embankment.
1,178 cubic yards of stone cut for locks.
3,350 cubic yards of rock, gravel, &c., excavated (pit of lock 1).
51 cubic yards rubble masonry laid (foundation of lock 2).
81 cubic yards stone broken for concrete (lock No. 2).

The present appropriation (1880), and that herein estimated for, will be required in continuing work on these shoals and in the necessary preparations for extending the improvement down to the coal-fields in Saint Clair County, Alabama; also, in completing certain minor improvements between Rome and Greensport.

Further details as to the present condition and the commercial interests involved in this improvement will be found in the following report of Lieut. W. L. Marshall, Corps of Engineers, the officer in immediate charge of this work.

This work is in the collection district of Mobile. The revenue collected at the nearest port of entry is unknown to me.

The original estimates of cost of improving the Coosa River are $552,347; amount appropriated, $225,000; amount expended, $121,021.59.

Money statement.

July 1, 1879, amount available	$94,827 57	
Amount appropriated by act approved June 14, 1880	75,000 00	
		$169,827 57
July 1, 1880, amount expended during fiscal year	65,849 16	
July 1, 1880, outstanding liabilities	6,128 31	
		71,977 47
July 1, 1880, amount available		97,850 10
Amount (estimated) required for completion of existing project		327,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		175,000 00

REPORT OF FIRST LIEUT. W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Rome, Ga., July 21, 1880.

SIR: During the past fiscal year work on the Coosa River has been confined to Whistenant's and Ten Island Shoals, a full description of which is to be found in the Annual Report of the Chief of Engineers for 1878. These shoals extend for 5 miles below Greensport. In this distance is a fall, over reefs and rocks, of 24 feet unequally distributed.

The project for the improvement consists in the construction of two dams and three locks, the canalization of Wood's Island Chute, and the excavation of a channel [illegible] feet wide and 3 feet deep at extreme low-water through the reefs at the head of the rapids.

Of this work, at the beginning of the fiscal year, there had been part of the channel excavation done, stone had been quarried for the dams, and part of the dam at Whistenant's Shoal built.

During the past fiscal year the channel excavation throughout has been completed with the exception of not exceeding 200 cubic yards at Rock Island Reef.

The dam at Whistenant's Shoal is essentially completed, and 1,100 feet of the base of the dam across the Coosa River, at lock No. 2, built and filled with stone to a height of 3 feet.

A coffer-dam was built in September about the site of lock No. 1, the lock-pit excavated, and the work of laying masonry began December 1, 1879; but, on the 13th of December, a freshet occurred which broke through both ends of the coffer and stopped work. Several attempts were made to repair the breaks, but the current in such a steep slope was so great as to render it impracticable. The dam was repaired in June and the work of laying masonry was resumed July 1, 1880. At present an effective force of masons and laborers are engaged thereat.

At lock No. 2 the embankment has been carried around its head to the island below, thus causing the water to be drained away from behind it, and the excavation for the lock-pit has been commenced. This embankment is to be carried above extreme high-water, and is now half done. The lock is to be connected with the dam above it by a high embankment or dam 16 feet in height, the material for which has been prepared. This embankment or dam is 400 feet long.

In August, 1879, a quarry was opened near lock No. 1 for the stone for that lock. The formation is a hard, fine-grained sandstone, nearly metamorphosed, and occurs in bowlders of various sizes and of very irregular shape, making the quarrying and cutting much more expensive than was foreseen.

Few stones came from the quarry with even an approximation to a butt or joint, in irregular masses, which must be hewn on all sides. An average force of fifty quarrymen and stonecutters have been kept at work in this quarry, and all the stone is now quarried and cut for lock 1, with the exception of the coping and some of the special stone for the lift-walls and miter-sills. These stones must be obtained from a limestone ledge found above the shoal, which has been stripped and the quarry opened. A third quarry, similar to the sandstone quarry at lock 1, was opened in January near the site of lock 2 for the purpose of getting stone for that lock. A force of from fifty to seventy-five cutters and quarrymen have been engaged in preparing stone for laying. About one-half the stone for lock 2 is cut, and the laying of masonry will begin as soon as the pit can be excavated. In neither of the sandstone quarries can stone for coping be had. There are no quarries on the Coosa between Rome and Greensport, and no stone within 50 miles of the works better than that we are forced to use.

It may be necessary, at considerably greater expense, to transport stone from a distance to complete the locks, but I still hope to be able to get stone for lock No. 3 in the vicinity of its site, where a limestone ledge has been found.

The work upon this improvement is nearly or quite one-half done, and it is evident that its cost will very materially exceed the estimate made for it, for the reason that the class of work done is of a higher grade. The foundations are more difficult than anticipated, the stone for building more difficult to obtain and cut, and the cost of labor and material generally is considerably higher than when the estimate was made.

In this connection I wish to call attention to the insufficient estimates of cost made for the work on the Coosa River. In Mr. Long's report, the cost of the locks is estimated at less than what it must necessarily cost to prepare their foundations.

No allowance is made for the increased height of walls to allow navigation during the moderate rises of the river, and shoals, with falls which will render open navigation impracticable, are considered navigable with channel excavation where locks will be necessary.

The levels and surroundings taken during this survey are all lost, and the maps, therefore, are not detailed enough to allow me to locate the necessary works or to check his estimates. Mr. Long, however, doubled the previous estimate, and with the exception of the locks, his prices are about what it is actually costing to do the work.

The object of the work at the Ten Island Shoals is primarily to throw open to commerce the Coosa River coal-fields. The country is thinly settled, and, with the exception of the rich mineral deposits, there is nothing in the present local business of the river which will justify the expenditure necessary for its improvement where it is not now navigable. Three locks and dams at Ten Island Shoals, and one at the head of Broken Arrow Shoals, will effect this most desired end. The prospective business of the river consists mainly in the transportation of this coal and iron.

If Congress does not see fit to embark in the general improvement of the Coosa River, it is at least advisable to penetrate as far as to this coal, even at Broken Arrow, 25 miles below Greensport. A dam at that point, even without a lock, in addition to the work at the Ten Island Shoal, will effect this. Afterwards, if thought advisable to carry the work further, the lock at Broken Arrow could be built without interfering with the navigation as far as to that point.

The next annual appropriation should be sufficient to build this dam and complete the work at Greensport, otherwise the locks at Greensport will be useless for some time after their construction on account of the obstructions between the foot of Ten Island Shoals and the coal-fields. These obstructions consist of reefs near Miller's Ferry and at Box Creek, over which it is impracticable to make a safe navigation without slackwater.

There are now employed in the trade of the Coosa River five steamers, two of which are small tugs employed constantly in towing logs to the saw mills at Gadsden; the others are employed in the trade of the Upper Coosa, are from 120 to 165 feet in length, and from 80 to 300 tons burden. A sixth steamer, 160 feet long by 30 feet beam, is being built at Gadsden, and another will be built in the spring of 1881 by the Georgia and Alabama Steamboat Company.

The business of the river consists in the transportation of cotton, pig-iron, lumber, and wheat, and return freights of guano, provisions, and merchandise.

There are 300 miles of river navigation above the obstructions at Greensport on the Coosa River and its tributaries, the Oostenaula and Coosawattee; 185 miles, from Rome to Greensport, being navigable throughout the year, and the remainder for six months in the year.

I have not been able to get any reliable statistics of the river trade. There are about 20,000 bales of cotton, 15,000,000 feet of lumber, 3,000 tons of guano, pig-iron, and general merchandise, and nearly the entire supply of corn, bacon, flour, and groceries for the population as far as to Broken Arrow Creek. The inhabitants of the valley have no other means of transportation except in the immediate vicinity of Gadsden, whence a short branch of railroad taps the Alabama Great Southern Railroad; but the principal demand for the improvement of the Coosa River below Greensport rises from the desire for cheap fuel, which the people hope to obtain by river transportation from the Coosa coal-fields.

There are nine blast-furnaces in the vicinity of Rome and the Upper Coosa Valley, which, from the growing scarcity of wood for charcoal; will, in a few years, have to go out of blast, or purchase coal at ruinous rates if the price of fuel is not very materially educed.

The iron ores of this vicinity are very superior, and the advantages for its manucture, when cheap fuel is once assured, are such as will necessarily cause a great delopment in this industry here. All the manufacturing industries of parts of North eorgia and Alabama depend for development and maintenance upon the improveent in question. At present consumers pay from \$3.25 to \$6 per ton for bituminous al, which makes manufacturing other than of the best grade of charcoal iron, un-

profitable in opposition to East Tennessee and more favored localities. Already the nail-works and rolling-mill located at Rome have closed, and the extensive car-wheel and foundry works here are contemplating removal.

The freights of the Coosa River are rapidly increasing in volume, so much so that, where six years ago a single line of steamers could with difficulty be maintained, we now have three opposition lines engaged in the traffic.

The lands are being rapidly homesteaded and cleared for cultivation, and the improvement of the stream is causing a demand for the land still in possession of the general government.

In the last annual report I asked for an appropriation of $23,000 to complete the work begun above Greensport. This recommendation is repeated, and, in my opinion, this amount is necessary to maintain the existing navigation and further to remove rock and gravel obstructions.

I would recommend appropriations as follows: Coosa River—Rome to Greensport, $23,000; Greensport to Selma, Rome, and Dalton Railroad, $170,000. A less appropriation than $100,000 should not be made, as that is the least amount that can maintain an effective force of skilled labor at work during the year.

Very respectfully, your obedient servant,

W. L. MARSHALL,
First Lieutenant of Engineers.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

V 10.

IMPROVEMENT OF OOSTENAULA AND COOSAWATTEE RIVERS, GEORGIA.

Work on these streams was begun on the 1st of July, 1879, and closed October 24, on account of high-water, and consists in the improvement of the natural channels by blasting rock and excavating gravel and bowlders from the shoals, and narrowing the water-way by wing-dams.

The work done during the past season was principally on the Coosawattee, and consisted in—

Rock blasted from channel	140 cubic yards
Bowlders blasted from channel	332 cubic yards
Gravel excavated from channel	313 cubic yards
Snags and overhanging trees removed	441
Drift removed from channel	102 cords.
Rock quarried for dams	807 cubic yards
Rock put in dams	1,513 cubic yards
Brush cut and put in dams	150 cords.

The improvement is designed to prolong the season of navigation which can only be carried on at moderately high-water.

The work is of a substantial and permanent character, and with occasional repairs will answer all the requirements of navigation.

Lieut. W. L. Marshall, Corps of Engineers, in immediate charge of the work, reports that—

The Coosawattee River is a small mountain stream, from 100 to 200 feet in width, with rapid current and short bends. It is navigable six months in the year as far as Carter's Landing, 45 miles from its mouth, or nearly to its head. The commerce of the river is small, consisting mainly of lumber, cotton, and wheat. It penetrates 30 miles from railroad transportation, and affords the only means of egress, except by wagons, for a small but rich agricultural country. During the past winter steamers have not navigated it, the farmers having constructed a kind of flat-boat, in which they float their produce to railroad at Resaca at trifling expense. These small barges are either pushed back with poles or hauled in wagons. One farmer, I understand, thus transported 9,000 bushels of wheat and 240 bales of cotton, at a cost less than one-third the steamboat rates.

The work on the Coosawattee River was directed to securing 2 feet navigation on that river when the Coosa River, at Rome, Ga., is 1 foot above extreme low-water, and it is confidently expected that this result will be obtained the present season.

In addition to the repair of such of the old dams as needed it, there was constructed during the past season 1,384 linear feet of dams, built of riprap, brush, and gravel. Most of these dams are durable; a few need more stone.

* * * * * * *

With the expenditure of the present appropriation ($2,000), all that can be done for the Coosawattee River, without slackwater, will have been accomplished, but the Oostenaula will require at least one full season's work for forty men to remove the rocks still obstructing the channel, or, say, $10,000.

The original examinations and estimates for this improvement were made in 1872 and 1874, and were designed to secure 3 feet depth of channel on the Oostenaula, and on the Coosawattee to secure good navigation for boats drawing 24 inches of water during nine months of the year.

The cost of improving both streams being estimated at	$28,208 50
The entire amount appropriated has been	24,000 00
Expended	21,089 97

Money statement.

July 1, 1879, amount available	$5,674 95	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$7,674 95
July 1, 1880, amount expended during fiscal year	4,764 92	
July 1, 1880, outstanding liabilities	132 75	
		4,897 67
July 1, 1880, amount available		2,777 28
Amount (estimated) required for completion of existing project		4,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1882		4,208 50

V II.

IMPROVEMENT OF ETOWAH RIVER, GEORGIA.

The instrumental survey referred to in my last report was completed and the report and estimates submitted to Congress December 18, 1879, and printed in H. Ex. Doc. No. 17, Forty-fifth Congress, second session.

The estimate was for improving 63 miles of river, so as to give a navigable channel 4 feet deep, which involved the building of 27 locks, at a probable cost of $2,276,663. In submitting this estimate, it was stated by me that—

The conclusion seems inevitable that the cost of the work would be vastly greater than the advantages to be expected would justify, but this is, of course, a question for Congress to decide.

No appropriation was made, and no work has been done other than that relating to the survey.

As there is no prospect that the balance of the appropriation for this stream can be profitably expended upon it, I would respectfully recommend that Congress be asked to make that amount available for the improvement below Rome, Ga., where the Etowah merges into the Coosa River.

Total amount appropriated act of August 14, 1876	$10,000 00
Amount expended	1,237 80

Money statement.

July 1, 1879, amount available	$9,940 27
July 1, 1880, amount expended during fiscal year	1,178 07
July 1, 1880, amount available	8,762 20

SURVEY OF ETOWAH RIVER, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., December 4, 1879.

GENERAL: I have the honor to forward herewith reports of Lieut. W. L. Marshall, United States engineer, and Assistant Engineer Ernst Ruhl, on the survey of Etowah River, made during the past summer, under authority of appropriation act of June 18, 1878. These reports give a full description of the river and proposed method of improvement, together with estimates of cost and some information as to the probable advantages to navigation.

The conclusion seems inevitable that the cost of the work would be vastly greater than the advantages to be expected would justify, but this is of course a question for Congress to decide. Should it be decided to begin work, it is earnestly recommended that at least one-third of the estimated cost may be appropriated the first year, so that the necessary preparations can be made for prosecuting the work vigorously and economically. Maps will be sent in a separate package.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF LIEUT. W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Rome, Ga., November 29, 1879.

SIR: I have the honor to return herewith the report of Mr. Ernst Ruhl, assistant in charge of the party for the survey of the Etowah River.

The survey was made in the months of May, June, and July, 1879, and the report is confined almost exclusively to a statement of the improvement necessary to secure a navigable channel, 4 feet in depth, from Rome, Ga., to the mouth of Little River, a distance of 63 miles, and an estimate of the cost of these improvements.

The Etowah River takes its rise in Lumpkin County, Georgia, and, after collecting the waters of many little mountain streams, flows in a direction a little south of west a distance, measured along its meanders, of about 110 miles, to Rome, Ga., where, uniting with the Oostenaula, it forms the Coosa, the main tributary of the Alabama River. Its drainage area is confined to parts of the counties of Lumpkin, Cherokee, Bartow, and Floyd, Georgia, rich agricultural counties, also abounding in minerals, gold, iron, manganese, and baryta, but little developed in mineral interests, and comparatively thinly populated. The lower portion of its valley is in a high state of cultivation, producing the cereals and cotton, but the surplus products of its immediate vicinity, for transportation to market, are insignificant within the limits of possible navigation, compared to the cost of obtaining transportation by river.

Throughout its course the Etowah is of the nature of mountain streams generally. From the mouth of Little River, in Cherokee County, where the survey begins, to its mouth, it will average 250 feet in width; its bed is obstructed with numerous rock reefs and steep bars, covered with bowlders and drift. At low-water its discharge is slight, and the reefs and bowlders in great part bare and exposed. Its banks throughout are high, save along a few narrow and low bottoms, and are well protected against wash by a thick growth of trees and aquatic shrubs and canes. It is subject to very

rapid rises, the full height of freshets being often attained in a few hours, and it nearly as rapidly subsides. The height of the greatest rises varies from 12 feet in the upper part of its course to 28 feet at Rome, where its slope is reduced. In addition to the natural obstructions its bed is filled with numerous fish-traps, and its course is dammed by two mill-dams. It is spanned by six bridges, the lower chords of which are barely above the high-water marks.

The present survey was restricted to that part of the river which may ultimately form a part of some through water line connecting the Mississippi Valley with the Atlantic seaboard, in connection with the rivers of Lower Georgia and connecting canals to be built between them.

From Rome to the mouth of Little River, a distance of 63 miles measured along its bank, the fall of this river is 232 feet or nearly 3.7 feet per mile. This fall, if uniformly distributed, would occasion a current, at moderate stages of water, when the friction against the bottom and sides of the channel is reduced, almost too great for successful up-stream navigation. As it is, however, the fall is not uniform, but the slopes are greatly increased at numerous points where the falls take place, over reefs and rock bars, with short pools of still water between them, the individual falls varying from a few inches, over narrow reefs, to from 4 to 16 feet within less than a mile, as shown in detail upon the profile.

It is impracticable to make a successful improvement of this part of the river without the application of a complete system of locks and dams, the low-water discharge of the river not being sufficient to fill any practicable channel which may be excavated through the reefs and rapids. To secure a navigable channel 4 feet in depth over this 63 miles of river, Mr. Ruhl estimates that 27 locks and dams are necessary, at a probable cost of $2,276,663, which, for a permanent improvement, is not a too liberal estimate.

There is at present no navigation upon the Etowah, and I have not been able to discover that it has ever been utilized even for navigating flat-boats or saw-logs down stream. There is no demand among the people for its improvement, unless a general desire to profit by any work whatever in their vicinity, to which they are not called upon directly to contribute, except a contingent and speculative one, *i. e.*, should the Coosa River be opened to the Gulf, or any of the through canal routes connecting the waters of the Coosa with the Mississippi River be inaugurated, then there will be a lively desire among the people to participate in benefits derived therefrom. At present the river leads to no market not readily and cheaply reached by railroad or wagon, and the entire present surplus of its valley, if shipped by river, could not maintain by any tolls the works necessary for its navigation.

Until the population becomes many times increased, and the products so much amplified by diversified industries as to make it the policy of the government to develop every possible means of inland transportation, there does not seem to me to be any occasion or need to improve the Etowah River. No part of it at present is more than 8 miles from railroad transportation.

Very respectfully, your obedient servant,

W. L. MARSHALL,
First Lieutenant of Engineers.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. ERNST RUHL, ASSISTANT ENGINEER.

CHATTANOOGA, *Tenn.*, *September* 2, 1879.

MAJOR: I have the honor to submit the following report of a survey, &c., of the Etowah River, in Georgia, commencing at the mouth of Little River, in Cherokee County, the starting point of a projected ship-canal uniting the waters of the Gulf of Mexico with the waters of the Atlantic Ocean, the contemplated water-way passing through the States of Alabama, Georgia, and South Carolina

The survey and field work performed in connection with it consisted of the running of a transit line on one side of the river, forming a basis upon which the topography of the river and its immediate surroundings were located. The distances from the transit line to the water's edge were measured with a tape-line at every point of deflection in the transit line, and to the water's edge on the shore opposite to it by using a stadia rod.

The lowest point of the river bed in a cross-section of the Etowah at the starting point was assumed as representing an elevation of 500 feet, and upon this assumption a series of levels were run on the transit line, and a check line of levels to test the former's correctness generally on the shore opposite to the transit line; elevations of water surface were taken about every 1,000 feet, and at shorter intervals where there appeared a sudden fall in the river. Whenever reliable information about the height

of flood of 1876 could be obtained, it was recorded and afterwards put on the profile. Benches were established and marked about every 50 stations, and recorded in the level book.

Soundings were taken opposite every station of the shore line, which, deducted from the elevation of the corresponding water surface, ascertained on the same day, gave the elevation of bed of river.

Cross-sections of the river bed were also taken, principally at places which will probably require work to increase the depth of water. Observations of stage of water were made and recorded three times per day on water-gauges established at Lovengood's Bridge, in Cherokee County, Douthard's Ferry, in Bartow County, and Rome, in Floyd County; also at a water-gauge put up near each camp for the time being, during the survey, for the purpose of arriving as nearly as possible at the figures of low-water mark, so as to be enabled to reduce the soundings in accordance with it.

From the observations of water-gauges and the known distance between them, the velocity of the water was ascertained, also from velocity observations taken with the use of floats, and found to average for the entire distance 2¼ miles per hour, and at some places not more than 1.6 miles per hour.

The contemplated depth of channel is 4 feet, and the width of the same where excavation is required = 60 feet.

Dams are assumed at 8 feet width on top, sloping on the side upstream at the rate of 1 foot vertical to 2 feet horizontal, and on the downstream side at the rate of one to one, built of dry masonry. Locks to be 210 feet long and 40 feet wide in the clear.

From the annexed profiles and maps of the river it is apparent that the cleaning out (removal of obstructions in it) would not improve to a great extent the facilities of navigating the same, on account of the irregularity of the slope of river bed and its great width in many places compared with the volume of water at its lowest stage, and the necessary improvements recommended consist, therefore, principally in the building of dams and locks, besides several channel excavations, whereof the estimated total cost amounts to $2,276,663, as detailed in the inclosed estimate. The high banks of the river are very favorable to slackwater improvements, being generally, as shown by the profile, on level with high-water mark, frequently above it, and wherever they are below the same it is, with few exceptions, not more than from 10 to 150 feet distance back of the transit line to the point where the elevation of natural surface reaches high-water mark.

All along the river between Rome and the mouth of Little River, stone for building dams and locks is within easy reach of the places where such are needed. Lumber can also be obtained from the numerous saw-mills near the river. Commencing just above the mouth of Little River, in Cherokee County, Georgia, this point of beginning is designated as station 0, and a stake driven in every 100 feet in distance and marked successively 1, 2, 3, &c.

Following the river down stream, the first obstruction met with consists of a mill-dam at station 37. Removing the dam would lower the water so much as to necessitate channel excavation for 1,300 feet above the dam and 800 feet below the same. Taking down the present dam and building a new one of 250 feet length and 7 feet height will not only preserve the proper depth of water above the dam, but will also raise the water between stations 37 and 42 to its necessary height. A lock of 5½ feet lift, with 10 feet additional elevation of walls, is required.

Material for building lock and dam can be obtained from the ridge opposite station 50 to station 60.

Between stations 53 + 50 and 59 + 50 for 600 feet the channel has to be deepened 1 foot, 60 feet wide, in solid rock.

In order to overcome the rapids and reefs between stations 112 and 148 and shallow water at 149, 150, 151, and 153, also 162 to 168, it will be advisable to put a dam across the river at station 165, and a lock of 6¼ feet lift. Rock for dam and lock can be obtained in the ridge on right side of river opposite stations 125 and 142.

At station 187 we find only 2 feet water, and an excavation of solid rock for a distance of 200 feet, averaging 1¼ feet in depth, will be required. At station 223 + 50 Lovengood's Bridge (a lattice bridge) spans the river; the lower chord of it being only 2 feet above high-water, it will be necessary to put either a draw in the bridge or abandon it entirely.

The shoals between stations 253 and 289 do not afford more than 2 feet of water, and since the slope of the river here would require too great an amount of excavation, a dam 8 feet high across the river at station 294 and a lock of 4½ feet lift will be preferable.

From station 294 we find excellent water down to station 374.

At station 332 Owl Creek empties into Etowah River, a water course spoken of as affording facilities for constructing a canal to unite the waters of Etowah River, consequently of the Gulf of Mexico, with the waters of a river flowing into the Atlantic.

Between stations 374 and 375 channel excavation of 1 foot in depth, 60 feet wide, and 100 feet long is necessary.

Between stations 388 and 392 + 50 channel excavation to the extent of 3 feet in depth is required. Between stations 430 and 435 + 50 channel excavation from 1 foot to 1½ feet deep is required. From the line dividing the county of Cherokee and the county of Bartow the shoals are of such length, and the descent of the river so rapid, that it becomes impracticable to improve the same by channel excavation or longitudinal dams, but cross-dams and locks appear to be the proper means of improvement between the eastern boundary-line of Bartow and Rome, the lower terminus of Etowah River.

The next dam to be constructed will be opposite station 541, at the head of Maddox Island, from the right-side shore to the island, so as to force the water in the left-side channel; the length of it will be 500 feet and its height 4 feet. At the foot of the island, opposite station 561, from the left-side shore to the island, another dam 125 feet long and 12½ feet high will be required, and a lock with 10 feet lift.

Between stations 565 and 570 channel excavation 2 feet deep will be required.

At station 594 to 595 + 50 channel excavation 1½ feet deep is necessary.

In order to force the water into the left-side channel at Pugh's Island it will be necessary to build a dam from the right-side shore, opposite station 595, to the head of Pugh's Island, 500 feet long and 3 feet high, and another dam at the foot of the island, opposite station 630, 175 feet long, 14 feet high, and a lock with 11 feet lift and 8 feet additional height of walls.

At station 674, a dam 600 feet in length, 13 feet in height, also a lock of 10 feet lift, with walls of 7 feet additional height, are necessary.

At station 711 + 50, a dam 600 feet in length, 19 feet in height, and lock of 15 feet lift, with walls of 5 feet additional height, are necessary. At station 746, a dam of 450 feet in length, 20 feet in height; also a lock with 15 feet lift and 8 feet additional height of walls required.

At station 771, a dam 500 feet long, 11½ feet height, and lock of 9 feet lift, with 8 feet additional height of walls necessary.

At station 801 + 50, a dam 400 feet long, 13 feet high, and lock of 10 feet lift, with 8 feet additional height of walls required.

At station 857, a dam 300 feet long, 14 feet high, and lock of 10 feet lift, with 8 feet additional height of walls required.

At station 944, the Western and Atlantic Railroad crosses the river. In order to enable steamboats to pass at all stages of water a draw in the bridge will be required.

At station 950 (Jefferson's Mill), a dam 325 feet long, 12 feet high, and a lock of 8 feet lift, with walls of 10 feet additional height required.

Between stations 977 + 50 and 982 the channel has to be deepened 2 feet.

At station 1012 (Tomlin's Mill), a dam 300 feet long, 9 feet high, and lock 5½ feet lift, with 10 feet additional height of walls required.

At station 1138, a dam 325 feet long, 10 feet high, and lock 7 feet lift, with 10 feet additional height of walls required.

At station 1207 there is a lattice bridge across the river belonging to the county; in place of putting in the draw the bridge might be bought for $25,000 and entirely removed.

At station 1233, a dam 275 feet long, 11 feet high, and lock of 8 feet lift, with 10 feet additional height of walls required.

At station 1303, there is a bridge belonging to Rockmart Railroad Company. A draw is necessary.

At station 1526, a dam 250 feet long, 12 feet high, and lock of 11 feet lift, with walls of 10 feet additional height required.

At stations 1593, 1596 + 75, it will be necessary to deepen channel 2 feet.

At station 1716 + 50, a dam 300 feet long, 10 feet high, and a lock of 7 feet lift, with 10 feet additional height of walls necessary.

At station 1860, a dam 300 feet long, 12 feet high, and lock of 8 feet lift, with walls of 10 feet additional height required.

At station 2064, a dam from right-side shore to head of island, = 600 feet long, 10 feet high, and lock at station 2081, with 11 feet lift, and 10 feet additional height of walls required.

At station 2211 + 50, a dam 375 feet long, 12 feet high, and lock of 8 feet lift, with 10 feet additional height of walls required.

At stations 2238, 2243, 2246, and 2249, deepening of channel required.

At station 2325, a dam 275 feet long, 9 feet high, and lock of 5 feet lift, with 10 feet additional height of walls required.

At station 2364, deepening of channel required. At station 2466, a dam 250 feet long, 14 feet high, and lock of 11 feet lift, with 10 feet additional height of walls required.

At station 2780, a dam 400 feet long, 11 feet high, and lock of 7 feet lift, and 10 feet additional height of walls required.

At station 2940, a dam 350 feet long, 11 feet high, and lock of 7 feet lift, with 10 feet additional height of walls required.

At stations 2945, 2947, 2951, deepening of channel necessary.

At station 3026, a dam 400 feet long, 10 feet high, and lock of 7 feet lift, with 10 feet additional height of walls required.

At station 3188, a dam 300 feet long, 10 feet high, and lock of 7 feet lift, with 14 feet additional height of walls required.

At station 3284, Howard street wagon-bridge; draw needed.

At station 3299, a dam 250 feet long, 9 feet high, and lock of 5 feet lift, with 10 feet additional height of walls required.

Station 3305 + 50, Selma, Rome and Dalton Railroad bridge; draw required.

Station 3323, Broad street wagon-bridge; draw needed.

The land adjoining the river on both sides is in a high state of cultivation. Corn, cotton, wheat, and occasionally oats, are raised successfully.

In a few instances the ridges bordering the main valley approach so near the water's edge that the foot of them forms the river-shore, in which case their sides are covered with timber.

The expected freight will consist principally of agricultural products. There is no doubt about immense amounts of mineral resources, especially in Bartow County, awaiting enterprising capitalists to develop them; they consist mainly of iron ore and manganese. Great expectations of gold to be taken from the river-bed are entertained by some people. Opposite the mouth of Alatoona Creek, 2 miles above the bridge of the Western and Atlantic Railroad, and from there for 2 miles up and along the north side of the river, very extensive iron-works and also a large flouring-mill were in operation before and during the war, being known by the name of "Etowah Iron Works." The entire establishment is now in ruins, and as far as could be learned the proprietors of the same and of the land (some 15,000 acres) pertaining to it have no inclination to utilize their enormous water-power and revive the iron manufacturing interest.

For the present, until the population and wealth of the country to be benefited by the navigation of Etowah River has materially increased, the mineral resources have been amply developed, and the immense water-power which will be made available by the work necessary for slackwater navigation may be utilized; until then there appears to be no necessity of incurring the expense for improvements of the Etowah River, especially as there are already sufficient facilities existing for transportation by the different railroads running alongside and crossing the river at various points: the Rome and Kingston Railroad starting at the confluence of Etowah and Oostanaula Rivers, and running alongside the Etowah on its very bank to a point within a short distance from Kingston; the Rockmart Railroad from Cartersville to Cedartown crossing the river 4 miles from Cartersville and running for several miles along its bank; the Western and Atlantic Railroad crossing the river 2 miles south of Cartersville. There is no point on the river between the site of the Etowah Iron Works and Rome which is more than 4 miles from a railroad; and there is no point on the river between the Etowah or Cooper's Iron Works and the mouth of Little River which is over 7 miles from the Western and Atlantic Railroad.

No portion of the river is at present navigated. Whenever it will be found advisable to begin actual work on the improvement of Etowah River, all dams and locks should be worked at simultaneously, and also the contemplated canal between a tributary of Etowah and some other river emptying into the Atlantic Ocean, because it will be a very long time before the local business of the part of the river surveyed will compensate for the cost of improvement, and it is therefore desirable to open a new continuous water-way at once in connection with it between the Gulf of Mexico and the Atlantic, so as to furnish through freight, since the reasonably to be expected local business will not be sufficient to justify the outlay for improving Etowah River.

Very respectfully, your obedient servant,

ERNST RUHL,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers, U. S. A.

ESTIMATES.

The lock walls are to be 5 feet wide on top, and the width of foundation [illegible] equals two-thirds of height of wall. The lock chambers, hollow quoins, miter-walls and sills, and coping to be cut stone; balance of masonry, rubble laid in cement. Concrete foundation one-third the lift of the lock. Price includes coffer-dam, bailing, pumping, and puddling:

Station 42.—Dam 250 feet long, $6\frac{1}{4}$ feet high = 28,843 cubic feet = 1,068 cubic yards, at $3.50	$3,738 00	
Removing part of old dam	250 00	
Lock $5\frac{1}{4}$ feet lift, with 10 feet additional height of walls	53,970 00	
		$57,9[illegible] 00

Station 53 + 50 to 59 + 50.—Solid rock excavation, 600 × 60 × 1 = 36,000 cubic feet = 1,333 cubic yards, at $3		$3,999 00
Station 165.—Dam 220 feet long, 10 feet high, 50,600 cubic feet = 1,874 cubic yards, at $3.50	$6,559 00	
Lock 6¼ feet lift, with walls of 10 feet additional height	57,590 00	
		64,149 00
Station 187.—Solid rock excavation, 200 × 60 × 1.5 .. 18,000 cubic feet = 666 cubic yards, at $3		1,998 00
Station 223 + 50.—Lovengood's Bridge to be bought and torn down		15,000 00
Station 294.—Dam 225 feet long, 8 feet high = 36,000 cubic feet = 1,333 cubic yards, at $3.50	$4,665 50	
Lock 4¾ feet lift, with 10 feet additional height of walls	51,325 00	
		55,990 50
Station 374 to 375.—Solid rock excavation, 100 × 60 × 1.0 = 6,000 cubic feet = 222 cubic yards, at $3		666 00
Station 388 to 392.—Solid rock excavation, 100 × 60 × (1.0 + 3.0 + 1.5 + 0.75) = 37,500 cubic feet = 1,389 cubic yards, at $3		4,167 00
Station 430 to 435 + 50.—Solid rock excavation: 1 × 60 × 50 = 3,000 1 × 60 × 100 = 6,000 1.5 × 60 × 100 = 9,000 1 × 60 × 100 = 6,000 24,000 cubic feet = 889 cubic yards, at $3		2,667 00
Station 541.—Dam 500 feet long, 4 feet high = 28,000 cubic feet = 1,037 cubic yards, at $3.50		3,629 50
Station 561.—Dam 125 feet long, 12¼ feet high = 33,984 cubic feet = 1,259 cubic yards, at $3.50	$4,406 50	
Lock 10 feet lift, with walls of 10 feet additional height	71,388 00	
		75,791 50
Station 565 to 570.—Rock excavation, 500 × 2 × 60 = 60,000 cubic feet = 2,222 cubic yards, at $3		6,666 00
Station 594 to 595 + 50.—Rock excavation, 150 × 1.5 × 60 = 13,500 cubic feet = 500 cubic yards, at $3		1,500 00
Station 595.—Dam 500 feet long, 3 feet high = 18,750 cubic feet = 694 cubic yards, at $3.50		2,429 00
Station 630.—Dam 175 feet long, 14 feet high = 71,050 cubic feet = 2,631 cubic yards, at $3.50	$9,208 50	
Lock 11 feet lift, with walls of 10 feet additional height	75,606 00	
		84,814 50
Station 674.—Dam 600 feet long, 13 feet high = 214,500 cubic feet = 7,944 cubic yards, at $3.50	27,804 00	
Lock 10 feet lift, with walls of 10 feet additional height	59,477 00	
		87,281 00
Station 711 + 50.—Dam 600 feet long, 19 feet high = 416,100 cubic feet = 15,411 cubic yards, at $3.50	53,938 50	
Lock 15 feet lift, with walls of 6 feet additional height	75,606 00	
		129,544 50
Station 746.—Dam 450 feet long, 20 feet high = 342,000 cubic feet = 12,666 cubic yards, at $3.50	44,331 00	
Lock 15 feet lift, with walls of 6 feet additional height	75,606 00	
		119,937 00
Station 771.—Dam 500 feet long, 11¼ feet high = 195,187 cubic feet = 7,229 cubic yards, at $3.50	25,301 50	
Lock 9 feet lift, with walls of 8 feet additional height	59,477 00	
		84,778 50
Station 801 + 50.—Dam 400 feet long, 13 feet high = 143,000 cubic feet = 5,296 cubic yards, at $3.50	18,536 00	
Lock 10 feet lift, with walls of 8 feet additional height	63,300 00	
		81,836 00
Station 857.—Dam 300 feet long, 14 feet high = 121,800 cubic feet = 4,511 cubic yards, at $3.50	15,788 50	
Lock 10 feet lift, with walls of 8 feet additional height	63,300 00	
		79,088 50
Station 944.—Draw in bridge of Western and Atlantic Railroad		20,000 00
Station 950.—Dam 325 feet long, 12 feet high = 101,400 cubic feet = 3,755 cubic yards, at $3.50	13,142 50	
Lock 8 feet lift, with walls of 10 feet additional height	63,300 00	
		76,442 50

Stations 977 to 982.—Rock excavation, 60 × 100 × (1.0 + 0.75 + 1.0 + 0.5) = 19,500 cubic feet = 722 cubic yards, at $3		$2,166 00
Station 1012.—Dam 300 feet long, 9 feet high = 58,050 cubic feet = 2,150 cubic yards, at $3.50	7,525 00	
Lock 5½ feet lift, with walls 10 feet additional height	53,970 00	
		61,495 00
Station 1207.—Stilesborough Bridge to be removed after being bought for		15,000 [illegible]
Station 1138.—Dam 325 feet long, 10 feet high = 74,750 cubic feet = 2,769 cubic yards, at $3.50	$9,691 50	
Lock 7 feet lift, with walls of 10 feet additional height	59,477 00	
		69,16[illegible]
Station 1233.—Dam 275 feet long, 11 feet high = 74,113 cubic feet = 2,745 cubic yards, at $3.50	$9,607 50	
Lock 8 feet lift, with walls of 10 feet additional height	63,300 00	
		72,90[illegible]
Station 1303.—Draw in bridge of Rockmart Railroad		15,00[illegible]
Station 1526.—Dam 250 feet long, 12 feet high = 78,000 cubic feet = 2,889 cubic yards, at $3.50	10,111 50	
Lock 11 feet lift with walls of 10 feet additional height	75,606 00	
		85,71[illegible]
Stations 1593 and 1596 + 75.—Rock excavation, 100 × 60 × (1 + 2 + 1) = 24,000 cubic feet = 889 cubic yards, at $3		2,66[illegible]
Station 1716 + 50.—Dam 300 feet long, 10 feet high = 69,000 cubic feet = 2,556 cubic yards, at $3.50	8,946 00	
Lock 7 feet lift, with 10 feet additional height of walls	59,477 00	
		68,42[illegible]
Station 1860.—Dam 300 feet long, 12 feet high = 93,600 cubic feet = 3,467 cubic yards, at $3.50	12,134 50	
Lock 8 feet lift, with walls of 10 feet additional height	63,300 00	
		75,43[illegible]
Station 2064.—Dam from right shore to head of island, 600 feet long, 10 feet high = 138,000 cubic feet = 5,111 cubic yards, at $3.50		17,[illegible]
Station 2081.—Lock 11 feet lift, with walls of 10 feet additional height		75,60[illegible]
Station 2211 + 50.—Dam 375 feet long, 12 feet high = 117,000 cubic feet = 4,333 cubic yards, at $3.50	15,165 50	
Lock 8 feet lift, with walls of 10 feet additional height	63,300 00	
		7[illegible]
Stations 2238 to 2249.—Rock excavation (1 × 60 × 75) + (1 × 60 × 100) + (0.5 × 60 × 125) + (1 × 60 × 140) = 22,650 cubic feet = 839 cubic yards, at $3		2,[illegible]
Station 2325.—Dam 275 feet long, 9 feet high = 53,212 cubic feet = 1,971 cubic yards, at $3.50	6,898 50	
Lock 5 feet lift, with walls of 10 feet additional height	52,185 00	
		59,0[illegible]
Station 2364.—Rock excavation, 1.5 × 60 × 200 = 18,000 cubic feet = 667 cubic yards, at $3		2,0[illegible]
Station 2466.—Dam 250 feet long, 14 feet high = 101,500 cubic feet = 3,759 cubic yards, at $3.50	13,156 50	
Lock 11 feet lift, with walls of 10 feet additional height	75,606 00	
		88,7[illegible]
Station 2780.—Dam 400 feet long, 11 feet high = 106,800 cubic feet = 3,955 cubic yards, at $3.50	13,842 50	
Lock 7 feet lift, with walls of 10 feet additional height	59,477 00	
		73,31[illegible]
Station 2940.—Dam 350 feet long, 11 feet high, = 94,325 cubic feet = 3,493 cubic yards, at $3.50	12,225 50	
Lock 7 feet lift, with walls of 10 feet additional height	59,477 00	
		71,7[illegible]
Stations 2945, 2947, and 2951.—Rock excavation (60 × 1.0 × 25) + (60 × 1 × 40) + (60 × 1 × 110) = 10,500 cubic feet = 389 cubic yards, at $3		1,16[illegible]
Station 3026.—Dam 400 feet long, 10 feet high = 9,200 cubic feet = 3,408 cubic yards, at $3.50	11,928 00	
Lock 7 feet lift, with walls of 10 feet additional height	59,477 00	
		71,405 [illegible]

Station 3188.—Dam 300 feet long, 10 feet high = 69,000 cubic feet = 2,556 cubic yards, at $3.50	$8,946 00	
Lock 7 feet lift, with walls of 14 feet additional height	75,606 60	
		$84,552 00
Station 3284.—Howard street wagon-bridge; draw required		10,000 00
Station 3299.—Dam 250 feet long, 9 feet high = 48,375 cubic feet = 1,792 cubic yards, at $3.50	6,272 00	
Lock 5 feet lift, with walls of 16 feet additional height	75,606 00	
		81,878 00
Station 3302 + 50.—Bridge at Selma, Rome, and Dalton Railroad; draw required		20,000 00
Station 3323.—Broad street wagon-bridge; draw necessary		10,000 00
Total		2,276,663 00

V 12.

IMPROVEMENT OF THE OCMULGEE RIVER, GEORGIA.

This river by its junction with the Oconee forms the Altamaha, and 'urnishes a natural outlet for the lumber, cotton, and other heavy pro- lucts of a large section of Central and Southeastern Georgia.

Below Macon the Ocmulgee flows through a heavily-timbered alluvial ountry, and its channel is therefore quite tortuous and shifting, and, s would naturally be expected, the principal obstructions are caused ither directly or indirectly by the caving in of the banks. The trees hat are undermined fall into the channel and form snags, and in many ases sunken rafts which, by retaining silt, form bars, and render the hannel impassable at low-water and unsafe at all times. The improve- ient consists almost entirely of the removal of these obstructions, and f the overhanging trees which are liable to become such. In a few ises, as at Hubbard's Shoals, rocks form the obstruction, but there will e much less rock excavation than was originally supposed. The work done by a small force of hired laborers, provided with steam derrick ats and other suitable appliances.

The steamer Clyde, which was employed on the work at the beginning the year, was discharged in September, and the force was employed building a new steam derrick boat, which was finished and put to rk in the channel in December.

During the year 963 snags and 84 overhanging trees were removed. ie snags are reported to have been unusually difficult to remove on count of their large size, the high water, and the fact that they were nerally located in the middle of the channel.

It is expected that the more serious obstructions, between the mouth the Ocmulgee and Hawkinsville, will be removed in time to allow the ton crop this year to be shipped by steamboat.

The following extract from the report of Assistant Engineer B. W. obel will give an approximate idea of the amount of commerce on this er:

uring the past year work in the Ocmulgee has been confined to that portion of it ween its mouth and Fodderstack Cut, about 65 miles; 1,134 snags have been taken , and most of these very large and deeply imbedded in sand. In one instance a ress stump was taken from mid-channel, measuring 144 inches at a point even with surface of the ground when standing. One of the worst places on the river, wn as Dick Swift Cut, employed the force several weeks; the current here is d, and the channel filled with logs and stumps, it was the terror of boatmen and smen. Most of the logs have been removed, and boats drawing 4 feet can now at low-water; a week or two more will clear it entirely.

From Barrow's Bluff to Jacksonville (about 3 miles) the river was so filled with logs that it seemed like one great raft. This has been removed and Swain's Cut cleaned out. The river was so obstructed here that boats could not pass at ordinary water; there is no difficulty now.

A great number of isolated logs have been taken out between Jacksonville and Dick Swift, 54 of these having been found above Guilder's Bluff. From Barrow's to Ashley's Cut, a great number of isolated logs were removed. The cut was found to be filled with a great raft, nearly closing the passage, while a sand-bar at the lower end rendered the water-way so narrow and tortuous that it was very difficult for an empty boat to pass. The logs have been taken out, and the sand-bank has washed away; there is now ample water for a boat drawing 4 feet. From this point to Reuben's Cut many isolated logs were removed. The cut has continued to widen and deepen; the old river is rapidly closing, and nearly the whole volume of water passes through the cut. Boats and rafts pass here without difficulty. There are some 10 to 12 feet in the channel, and no snags. Trees sometimes come in from washing of the banks, and these have to be looked after. From this point to Horse Creek the only obstacles met with were isolated snags; these were numerous.

At Horse Creek there was a raft of sunken logs, known as "Horse Creek snags." These have been taken out. Below this is a place very dangerous for rafts, known as Lower Winslow Point. A sketch of this point is herewith inclosed.

Boats pass here, but for the convenience of rafts the cut into the lake or old river should be opened. Booms, such as I described to you in a previous letter, should be placed across several sucks or breakovers for the reasons stated.

Immediately above Burkett's Ferry a very dangerous rock was reported by pilots in mid-channel. This rock was recently fished out, and proved to be an immense cypress stump.

There are no obstacles between Burkett's Ferry and Hubbard's Shoal except logs; most of these have been removed.

In all parts of the river some logs yet remain; these have been missed during high water, but are not serious obstacles except at seasons of extraordinary low-water such as we had in 1879. When such low-water again occurs they can be gotten out. It has not been possible to remove them during such high-water as has prevailed during the past winter. At Hubbard's Shoal the deepest water was filled with logs, forcing boats to make their way over the shallower portion of the rock bar. These have been removed and since then the pilots have not complained. Work will no doubt be needed to secure a free passage at extreme low-water.

At Tilman's Bar there are some 7 or 8 feet at low-water; from this point to the mouth of the river the channel is clear.

In December last the snag-boat McArthur was ready for service and dropped down from Hawkinsville to the mouth of the river.

Work was begun here removing logs that lay in mid-channel; many of these were so deeply buried in sand that we had not until then the power to lift them. Many of these were found between the mouth of the river and the Macon and Brunswick Railroad bridge, some that interfered with steamboat navigation, and many others that seriously endangered rafts; upon some of these logs a great number of rafts are said to have been wrecked. All of those known to river men have been removed.

The snag-boat has gradually worked her way up stream and is now above Dick's Swift and about 65 miles from the mouth of the river. * * * From Fodder's Cut to Lampkins, ¾ of a mile or more, was one of the worst places on the river.

The channel seemed to be a sunken raft covered with sand through which the branches and roots of trees stuck up so thick that a boat drawing 15 inches could not pass. I am satisfied that the jetty system adopted here and on the Oconee will remove all trouble from sand-bars. Such jetties are easily constructed and will never wash away.

Three steamboats are now plying upon the Lower Ocmulgee. They make trips from Darien and Savannah to Wilcox's Lake and Hollingsworth's Landing, from [illegible] to 100 miles from the mouth of the Ocmulgee. Two other boats are building, one at Tilman's Landing, and the other at Hawkinsville, while others still are in contemplation.

During the first four months of the year there was landed and shipped from the railroad station at the Macon and Brunswick Railroad bridge, the following articles: Guano 8,228 sacks; rosin and spirits turpentine, 2,259 barrels; cotton, 38[illegible] bales, and a fraction less than 200,000 pounds merchandise, including corn and bacon.

As this is but a way station from which freight must be transhipped by rail from either direction, it is not likely that any large proportion finds its way here but goes in bulk to Darien or Savannah, or from these points up the river.

In Hawkinsville about $1,000,000 worth of supplies of various kinds are distributed, and 20,000 bales of cotton are received annually.

Cotton is shipped now by rail to Savannah at a cost of $1.80 per bale: by river it could be shipped for $1, or less. This cotton is worth $1,000,000; 100,000 pounds of

wool, valued at $33,000, is also shipped from here, while 60,000,000 feet of lumber are also rafted annually out of the Ocmulgee.

Arrangements are being made to ship cotton to Savannah by water so soon as the river is open. Below Hawkinsville some 3,000 to 4,000 bales of cotton are raised, and this more accessible to the river than to other transportation. According to the report of shipments from Ocmulgee Station, lower down, an average of 1,000 bales is annually received from the river at that point, and this does not cover the entire amount produced within range of the river.

There are a great many turpentine stills scattered through this section. These are seeking the heavy forests along the river where transportation can be had.

All these interests suffer on account of the obstructions in the river, but most of all the lumber trade; so great are the losses from this cause, that one firm (the Georgia Land and Lumber Company) has offered to give the necessary timber for the booms, and furnish to the government, free of cost, twenty or more hands to work on the river.

The original estimate for improving the Ocmulgee River, Georgia, was	$56,240 00
Amount appropriated	44,000 00
Amount expended	35,891 69

Money statement.

July 1, 1879, amount available	$13,010 39	
Amount appropriated by act approved June 14, 1880	7,000 00	
		$20,010 39
July 1, 1880, amount expended during fiscal year	11,902 08	
July 1, 1880, outstanding liabilities	524 45	
		12,426 53
July 1, 1880, amount available		7,583 86
Amount (estimated) required for completion of existing project		12,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		12,240 00

V 13.

IMPROVEMENT OF OCONEE RIVER, GEORGIA.

The description just given of the Ocmulgee River and its obstructions, ınd the method of improvement adopted, is, without material alteration, ›pplicable to the Oconee.

At the beginning of the fiscal year the new steam derrick-boat, built ›t Milledgeville, had just worked its way down, with much difficulty, hrough snags, rafts, &c., to the Georgia Central Railroad bridge, which ›rmed the upper limit of the work authorized by the appropriation act. 'rom this point she worked down the river, removing, *en route*, 565 nags, and 13 overhanging trees, reaching Dublin on the 21st of Janury, since which time she has been at work between Dublin and the ıouth of the river, where she has removed 235 snags and 7 overhanging 'ees.

Further details relating to work, and to the advantages to be expected om it, are given in the following extract from the report of Assistant ngineer B. W. Frobel:

The work on this part of the river (below Dublin) so far satisfies me that the estiate of $35,000, submitted some time ago, will cover the cost of improving it from its ›uth to Dublin. There are no rock shoals here that cause serious trouble. Logs ıl sand-bars, which result from sunken logs, are the difficulties in the way just now, ıl jetties, such as those at Buckeye Creek, will probably cure these troubles.

There are a great many sucks and breakovers, similar to those on the Ocmulgee. ıese are dangerous and often destructive to rafts. Booms, similar to those I have commended for the Ocmulgee, should be placed across them. They are generally

not troublesome until the water rises 5 or 6 feet, then it rushes with great violence through them, and rafts are drawn in and wrecked. One such "suck" on the Ocmulgee costs the Georgia Land and Lumber Company $1,000 yearly in this way. In some cases trees near the banks can be used to anchor the booms, instead of piles. When necessary a pile-driver can be rigged on either of our boats with little cost.

There are three steamboats plying on this river and a large barge. Another steamboat will soon be built for the same purpose. One of these boats (the Colville) distributed during the past spring 3,000 tons guano. Fifteen thousand bales of cotton are annually raised within easy reach of the landings, worth $750,000. Laurens and Montgomery counties alone produce 300,000 pounds wool. There are two turpentine distilleries on the banks of the river. One of these produces 6,000 barrels rosin and 800 barrels spirits of turpentine, and the one which has just been built is of equal capacity. Between 30,000,000 and 40,000,000 feet of lumber are also floated annually out of this river. This trade suffers seriously from an obstructed river. All the people employed in these various industries have their chief and almost only means of transportation furnished by the river. The value of products seeking this route does not fall much below $1,200,000, while supplies of all kinds, including corn and bacon, along a line of 200 miles of navigable water are all transported over it, and in the aggregate amount to a very large sum. The agent at Ocmulgee Depot reports that 200,000 pounds of merchandise were shipped up the Ocmulgee from that point during the past four months. The people on the Oconee are more dependent upon river transportation, and we must remember that as these boats ply from Darien and Savannah most of their freights are shipped from those points.

It will probably be necessary to keep a snag-boat employed on this river for several years, at an annual cost of about $3,000.

This work is in the collection district of Brunswick, Ga.

The estimates made for this work were	$15,000 00
Amount appropriated	13,000 00
Amount expended	10,723 5

The original estimate just given was made by Mr. Gould in 1874 (see Report of Chief of Engineers, 1875, pp. 42 to 45), and it is now evident that a much larger sum will be required to remove all the obstructions to low-water navigation. Assistant Engineer Frobel states that, from a recent examination, it will cost $35,000 to complete the improvement from Dublin to the mouth of the Oconee, and gives the following reasons for the discrepancy in the estimates:

I would respectfully invite your attention for a moment to the difficulty, and I might say impossibility, of arriving at anything like certainty in estimating the number of logs in rivers of this character. Mr. Gould places the entire number of logs and snags between the bridge and Dublin at 275. Five hundred and fourteen have already been taken out, and there are still several places where more work is needed, probably sufficient to employ a boat and party two or three months.

Should Congress therefore decide to complete this work in accordance with the foregoing suggestions the estimate of cost must be increased $35,000.

Money statement.

July 1, 1879, amount available	$7,317 85	
Amount appropriated by act approved June 14, 1880	1,500 00	
		$8,817 85
July 1, 1880, amount expended during fiscal year	6,541 50	
July 1, 1880, outstanding liabilities	397 16	
		6,938 66
July 1, 1880, amount available		1,879 19
Amount (estimated) required for completion of existing project		2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		10,000 00

V 14.

SURVEY OF CHATTAHOOCHEE RIVER ABOVE COLUMBUS, GEORGIA.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., November 19, 1879.

GENERAL: I have the honor to submit herewith a report on the survey of the Chattahoochee River above Columbus, Ga., authorized by appropriation act of June, 1878.

Steps were take to procure instruments for beginning this survey early in the season, but owing to the prevalence of the yellow-fever epidemic, which interrupted travel and threatened to overrun this whole section, the surveying party was not fairly at work in the field until January 8, 1879. The exceptionally cold weather and high water at that time rendered it difficult and tedious to make the survey; and it was not until the 6th of May that the field party, having completed its work, was disbanded.

Mr. D. L. Sublett was detailed to make this survey, with orders to report for additional instructions to Assistant Engineer B. W. Frobel, at Atlanta.

For reasons not necessary here to state, the report of Mr. Sublett was not completed so far as the estimates were concerned, but in justice to both of these gentlemen and in order to secure the full weight of their opinion as to the practicability, cost, and other matters upon which they seem to have arrived at different conclusions, I append both reports as they were submitted. In these reports will be found a full description of the river surveyed and of the proposed method of improvement, together with estimates of cost and statements of the advantages to be expected from the proposed improvement. To avoid repetition I shall refer only to those points which appear to require further or different consideration from that given in the appended reports.

The most important element to be considered in connection with the feasibility of this improvement is the *amount and distribution of fall to be overcome by locks and dams.*

From the following diagram it will be seen that the entire fall between Thompson's Bridge (near Gainesville) and Columbus, a distance of 215 miles, is 751 feet, and that this fall is very unevenly distributed, nearly one-half of it, or 362 feet, occurring between West Point and Columbus, in a distance 34 miles.

The improvement of the *second* section, viz, from the Western and Atlantic Railroad bridge, near Atlanta, to West Point, appears entirely feasible, the fall being only 162 feet in a distance of 108 miles, and there being only about 36 feet of this fall requiring to be overcome by locks and dams.

The feasibility of improving either the *first* or *third* sections, whether considered with reference to the magnitude and cost of such works as the government has undertaken elsewhere, or to the advantages to be expected from this particular improvement, is at least extremely doubtful, since the cost of the improvement and of maintaining and operating the necessary locks would be out of all proportion to the advantage to be derived from it. This will be apparent from the following estimates. In preparing these estimates the following principles have been kept in view:

1. The locks must not only provide for the actual fall of the river at low-water, but each lock must have a sufficient lift to allow for at least

an ordinary high-water stage. It would of course be useless to build locks which would be overflowed and rendered impassable, and perhaps seriously damaged by ordinary floods. Taking the average rise at 28 points, as given by the survey, we find it 17½ feet. A river generally rises less above a dam or shoal than below it, but we could not safely reduce the above average on that account more than one-third, which would leave 11½ feet as the least average rise that must be provided for at each of the 42 points where locks would be required. If any of the locks were grouped together in a closed canal, this would apply to the upper lock only; but they are all in the bed of the river, and detached from each other. It is necessary, therefore, that in addition to the 42 locks estimated for to overcome the fall of the river, averaging 11.04 feet lift feet each, there must be 42 more guard or regulating locks, averaging 11½ feet lift each, to provide for the ordinary changes of water-level. In three or four cases the difficulty could be overcome by giving additional lift to the locks already estimated for, but at all other points this would give a lift greater than would be economical, and additional locks would be cheaper.

2. It would not be allowable to use timber in either locks or dams except where it would *certainly* be kept wet at all times. In this climate even the best yellow-pine timber, if alternately wet and dry, lasts but a few years, and if it were exposed to the weather in this work it is certain that before half of the locks required for the improvement could be built, by anything like ordinary appropriations, the first ones would be rotten and unserviceable. It is not safe, therefore, to estimate for anything short of substantial rubble masonry or concrete. A single one of the 84 locks getting out of order would obstruct navigation and render the whole improvement useless for the time being, and it is therefore important that nothing but durable materials should be indroduced.

3. As this proposed improvement is for future rather than present use, and as the locks when once made cannot be easily enlarged, the size of the locks should be such as to omit the largest steamer that would be likely to come up the river at any time within the next [illegible] years. The proper dimensions to accomplish this are of course a matter of opinion, but it would seem probable that boats 200 feet long and 40 feet over all may at no distant day navigate the Lower Chattahoochee; and if so, the locks should be capable of passing them.

4. The cost of excavating sites for locks and leveling up to grade will vary according to the location and nature of materials upon which each lock is founded, and the survey was not sufficiently detailed to determine all these points; but taking the average actual cost of 5 locks at Muscle Shoals as a basis, we may conclude that this item of expense cannot fall short of $9,000 for each lock. The locks at Muscle Shoals were exceedingly favorably located, the strata of limestone being nearly horizontal, and there was but little expense for coffer-dams. These considerations would more than compensate for the difference in the size of the locks. The average cost of preparing sites for 5 locks was $8,615 exclusive of engineering and contingencies.

5. The cost of gates and wickets, and the necessary winches, &c., for operating them, will not fall short of $5,000 for each lock of average lift, viz, 11 + feet.

6. The annual cost of maintaining and operating the proposed locks and dams should be considered with reference to the probable amount of commerce that would be created and benefited by the improvement. This is more especially a question to be decided by Congress, but as

bearing upon the subject I have added an estimate of the probable cost of maintenance, capitalized, which represents the minimum expenditure that can be expected. The smallest force of lock-tenders that could be expected to work the locks and attend to minor repairs would be 4 men, which, at $1 a day each, for the 42 places where locks will be required, would cost $168 per diem, or $61,320 per annum, which capitalized at 4 per cent. would represent a permanent investment of $1,533,000.

7. Another very considerable item of expense would result from the toll-bridges, railroad-bridges, and mill-dams along the river, which would be more or less interfered with. This would require the payment of damages to the private owners, or would involve additional expense in the work itself to avoid interfering with these structures, of which there are at least a dozen between Gainesville and Columbus. The amount of money involved can only be ascertained by a careful examination into the circumstances of each case. The question of overflowing private lands would also be liable to add materially to the cost of the proposed improvement.

8. As to the amount of commerce that may be anticipated, it may be suggested that the river is crossed by four railroads, and is nowhere more than 15 miles, and on an average only about 7 miles, from a railroad; and the general direction of the river is nearly at right angles to the lines which commerce naturally seeks, from the great Mississippi Basin to the Atlantic Ocean. It is not likely, therefore, to form a link in any through or trunk route.

9. Should Congress decide to commence work on one or more sections of this river, it is earnestly recommended that at least one-third of the amount estimated for the proposed work be appropriated the first year. For example, if the second section is appropriated for, the amount should be one-third of $486,474, or say $160,000. In beginning a large work of this kind, a considerable outlay is necessary for machinery, tools, and supplies, and unless due allowance is made for these items, which are necessary for the economical prosecution of the work, the whole appropriation will be exhausted in preliminary operations, without making any progress with the actual work of improvement.

It is also to be remembered that no advantage whatever will be derived from the money expended until a sufficient length of the river is made navigable to induce private parties to build steamboats and engage in commerce.

ESTIMATE.

SECTION I.—THOMPSON'S BRIDGE TO WESTERN AND ATLANTIC RAILROAD BRIDGE, 73 MILES.

Channel excavation, 3,669 cubic yards, at $5	$18,345
Canal excavation, 400 cubic yards, at $3	1,200
Timber for dams, 1,888,356 feet, at $15 per M	28,325
Stone in crib-dams, 41,931 cubic yards, at $1	41,931
(These four items from Assistant Engineer Frobel's estimate.)	
28 locks, 7 to 16 feet lift, averaging 11 feet, at an average cost of $42,140 each, including excavation, foundation, gates, wickets, &c	1,179,920
	1,269,721
Add 20 per cent. for engineering and contingencies	253 944
	1,523,665

SECTION II.—WESTERN AND ATLANTIC RAILROAD BRIDGE TO WEST POINT, GA., 108 MILES.

Channel excavation, 10,773 cubic yards, at $5	$53,865
Wing and riprap dams, 3,225 cubic yards, at $2.10	6,772
Timber for dams, 921,594 feet board measure, at $15 per M	13,824
Stone in crib-dams, 13,121 cubic yards, at $1	13,121
Iron drift-bolts, &c., 6,213 pounds, at 6 cents	373
(These five items from Assistant Engineer Frobel's estimate.)	
8 locks, 6 to 11 feet lift, averaging 10 feet lift, at an average cost of $39,680 each, including excavation, foundation, gates, wickets, &c	317,440
Add 20 per cent. for engineering and contingencies	81,079
	486,474

SECTION III.—WEST POINT, GA., TO COLUMBUS, GA., 34 MILES.

Channel excavation, 9,717 cubic yards, at $5	$48,585
Canal excavation, 17,777 cubic yards, at $1	17,777
Timber for dams, 6,322,704 feet board measure, at $15 per M	94,840
Stone in crib-dams, 138,051 cubic yards, at $1	138,051
(These four items from Assistant Engineer Frobel's estimate.)	
48 locks, lift from 7 to 16 feet, averaging 11¼ feet, at an average cost of $43,430 each, including excavation, foundations, gates, wickets, &c	2,084,640
	2,383,893
Add 20 per cent. for engineering and contingencies	476,779
	2,860,67[illegible]

Total cost section I	1,523,65[illegible]
Total cost section II	486,4[illegible]
Total cost section III	2,860,67[illegible]
	4,870,[illegible]
Add annual cost of operating, capitalized at 4 per cent	1,533,[illegible]
Aggregate	6,403,[illegible]

The maps of this survey consist of a large number of detailed sketches showing the principal obstructions, and location of proposed improvements, and will be forwarded as soon as they are copied.

Very respectfully, your obedient servant,

W. R. KING,
Major of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF MR. B. W. FROBEL, ASSISTANT ENGINEER.

ATLANTA, GA., *July* 5, 1879.

MAJOR: I have the honor to submit the following report of a survey of the Chattahoochee River from Thompson's Bridge, in Hall County, to Columbus, Ga., made under orders communicated to me by you December 3, 1878.

On the 10th of January, 1879, the survey was begun at Thompson's Bridge, the field work being under the direction of Mr. D. L. Sublett, and ended on the 5th of May at Columbus. The weather for most of the time was favorable for the prosecution of field work, with an unusually low stage of water for the season.

The Chattahoochee rises in Northeast Georgia, and after traversing the State in a southwest direction to West Point, takes a course nearly due south, and for about 400 miles forms the boundary between Georgia and Alabama. It then enters West Florida, and flowing across that State empties into the Gulf of Mexico.

From the seaboard to Columbus, a distance computed by water at 400 miles, there is constant navigation for boats capable of carrying 750 bales of cotton, and this portion is being improved by the removal of bars and other obstructions.

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The river passes through the following counties in Florida, which in 1870 had, according to the United States census, an aggregate population of 22,634, viz: Franklin, Liberty, Calhoun, Gadsden, and Jackson. It also passes along the following counties in Alabama: Henry, Barbour, Russell, and Chambers, with a population of 82,698, while in Georgia 21 counties are adjacent to its waters with a population of 231,719, making an aggregate of 337,051 people living along its banks from where the survey began to the Gulf of Mexico. This enumeration, however, was made in 1870. Since then the population in some of these counties has greatly increased. For instance, the population of Atlanta in 1870 was 21,798; it is now about 42,000, or double what it was in 1870. Adding for the other counties 10 per cent. of increase, we have about 400,000 people who would be directly benefited by the proposed work.

The river for its entire length flows through a rich and highly productive country. The census of 1870 gives $22,606,980 as the aggregate value of farm products in the counties upon its banks. This value, no doubt, has been much increased during the ten years past, and would be greatly increased still were some better and cheaper means of transportation afforded this section. The census of 1870 gives 1,240 factories and workshops of every description in the counties named, employing a capital of $6,398,603, and producing annually articles whose value is given at $9,166,465. Of this amount $1,760,750 is invested in cotton-factories, 12 of which run 80,000 spindles. Comprised in the manufacturing establishments enumerated above, there are 242 flour and grist mills, 134 saw-mills, 1 foundry, 21 tanneries and other factories, and most of these situated immediately upon the Chattahoochee and its tributaries. The great gold region lies upon the waters of this stream and around the head of the proposed improvement. Much of this country is rich with magnetic iron ore and other minerals of great value could some means of transportation be afforded.

In a distance of nearly 700 miles the river is approached by railroads but six times, viz: near Atlanta, near Newman, at West Point, at Columbus, at Eufaula, and Chattahoochee. Above Atlanta the counties north of the river are without transportation except by wagon-roads, and this is the case also between Atlanta, West Point, and Columbus. The improvement of the river would afford a cheap and certain means of getting to market to a large and very rich agricultural section. Being fed principally by living streams, it is not subject to the extreme fluctuations that characterize many other rivers.

For convenience the survey is divided into three sections. The first section embraces that portion from Thompson's Bridge to Western and Atlantic Railroad crossing.

SECTION I.

This section is 73 miles long, the initial point at Thompson's Bridge being 989.02 feet above tide in the Gulf of Mexico.

At the railroad crossing the elevation is 762 feet, giving a fall of 227.02 feet in the distance named. The regimen of the river here is fixed, the bottom and banks being uniformly of rock, and with an average width of water surface of about 300 feet. Twenty-one shoals were found in this section, with an aggregate fall of about 160 feet. Between these shoals the current is usually gentle, with long stretches of unobstructed water sufficiently deep for a navigation not exceeding 3 feet.

The estimates submitted contemplate locks 150 feet long between miter-sills and 35 feet wide, and designed to accommodate the largest boat now navigating the river. Head and tail walls to be of masonry laid in cement. Intermediate walls of cribs filled with stone. The sides of these and the bottoms of locks to be double planked. It is proposed also to use crib-dams; these cribs to be made of round timber of from 14 to 16 inches in diameter, double planked, and with intersections and joints secured by iron bolts. An abundance of such material may be had wherever these works are needed, and close at hand.

The elevation of the water surface at Thompson's Bridge was obtained by a transfer of levels from the railroad track at Gainesville Depot, and the result as given based upon estimated low-water at the point indicated. All soundings are reduced also to low-water.

From Thompson's Bridge to Shallow Ford is about 3 miles, and no work is needed here the river being about 200 feet wide and from 4 to 8 feet deep. The shoal begins a short distance above the ford, and is 5,500 feet long, with a fall of 6.71 feet.

The river here is something over 300 feet wide, the channel at the upper end being divided by an island 1,600 feet long. The best water is found in the right-hand channel. A dam 275 feet long will be needed here, closed by a lock of 10 feet lift. For about ¾ of a mile below this the water is good to

Johnson's Shoal.—The river here is 200 feet wide, with a fall of 3.17 feet in 3,600 feet. The channel over this has a minimum depth of 3 feet. Three wing-dams, each 100 feet long, placed at proper intervals, is all that is needed. Below this shoal there is good water for 1½ miles to

Mooney's Shoal.—This is 5,600 feet long, with a fall of 3.25 feet; the river varying

from 150 to 250 feet in width. The obstruction consists of a fish-trap dam at the head of the shoal and a rock-bar at the lower end. Four hundred and forty-four cubic yards of rock must be removed to give the required depth. Below this there is 4½ miles of good water to

Overby's Shoal.—This shoal is immediately above the mouth of Chestatee River, and is 300 feet long, with a fall of 6.92 feet; the river being on an average of 350 feet wide. A dam at the mouth of the Chestatee 200 feet long, closed by a lock of 7 feet lift, will be necessary. Below this for 2¼ miles there is good water to

Brown's Mill.—This shoal is 8,500 feet long, with a fall of 1.692 feet. The river here widens from 250 to 600 feet. A dam 600 feet long near Brown's Mill, with a lock of 7 feet lift, is the first work required. Another dam 260 feet, with lock of 10 feet lift, should be placed at lower end.

At *Souther's Ferry* no work is needed. For 10 miles below Brown's Mill the water is good. Then we come to

Pirkle's Shoal.—This is 4,600 feet long, with a fall of 3.9 feet. The river varies from 300 to 400 feet in width. The obstruction consists of 3 rock reefs, with pools of deep water between. The channel over these requires deepening, and this can be done by the removal of 300 cubic yards of solid rock. Two miles farther down is

Winding Shoals and Garner's Bridge, which is 11,820 feet long. This includes the entire distance from Hammond's Island to a fish-trap shoal below Bowman's Island, with a fall of 16.90 feet. A dam at the fish-trap shoal 350 feet long, with a lock of 16 feet lift, will flood the entire obstruction to the proper depths. Four miles from this is

Mathew's Fish-trap Dam.—This is a ledge of rock with about 4 feet of water on it. The fish-trap dam should be removed and the ledge deepened. This requires the removal of 88 cubic yards of rock. For 12 miles there is good water to

Jones's Ferry.—This shoal is distributed over 1,200 feet. It consists really of 3 shoals with deep water between them. The first is at Jones's gin-house. The river here is 420 feet wide, with a fall of 2.30 feet. The water above the ledge is 15 feet deep, and by removing part of the ledge the trouble can be cured. There is 6,300 feet of deep water below this to the second ledge. Here there is a fall of 0.55 foot, with 4 feet of water above and 5 feet below it. There is 4,600 feet of deep water between this and the third ledge. There is a fall here of 0.30 foot, the river being 260 feet wide. Deepening the channel over these ledges is all that is needed, and this can be done by the removal of 2,620 cubic yards of rock. Ten miles below this is

Island Shoal.—This shoal has a fall of 9 feet, distributed over 5,000 feet. The river is from 400 to 800 feet wide, the channel being divided by two islands. A dam below the lowest reef, 500 feet long, with lock of 9 feet lift, will pond the entire shoal. Six miles from this is the beginning of

Roswell Shoal.—10,400 feet below the head of the shoal is Kelpin's; the river in the distance has a fall of 13.28 feet and averages about 600 feet in width. A dam 600 feet long should be placed here, with a lock of 12 feet lift. From Kelpin's to the foot of Bull's Sluice is nearly 2 miles. The river between these points varies greatly in width, the channel being divided by many small islands. There is a fall of nearly 40 feet in this distance, and the only improvement practicable is by ponding. This can be done by a dam at the head of Bull's Sluice 400 feet long, with lock of 10 feet lift. Three thousand feet below this, another dam 650 feet long, with lock of 15 feet lift, and another dam at the lower end of the sluice 500 feet long, with lock of 15 feet lift. This will pond the entire shoal. The next obstruction is known as

Cochran's Shoal.—No work will be needed here, as a dam at the upper end of what is known as the Devil's Race Course will flood it. The next shoal, 2 miles below this, is called

The Devil's Race Course.—The river here is 450 feet wide, with a fall of 19.95 feet, measuring from the head of Cochran's Shoal. A dam just below the first fall, with a lock of 12 feet lift, will flood Cochran's Shoal. Another dam at the lower end of the course will flood the whole. This dam will be 456 feet long, with a lock of 13½ feet lift. About one mile below this is

Dimpsey's Ferry.—The river here is 300 feet wide and the shoal 5,200 feet long, with a fall of 10 feet. A dam 300 feet long with lock of 10 feet lift will be necessary. The next shoal is found just below

Pace's Ferry.—The river here is 300 feet wide, filled with sunken reefs, and has a fall of 6.50 feet in 4,264 feet. It will need a dam 300 feet long, with a lock of 6½ feet lift.

Buzzard's Roost is the next obstruction. The river is 379 feet wide, the shoal consisting of a reef 20 feet long. This should be removed, involving 88 cubic yards solid rock excavation. The next obstacle is known as

De Four's Ferry.—This, like Buzzard's Roost, is simply a narrow reef, through which the channel should be deepened. The removal of 88 cubic yards of rock will do this.

The estimated cost of the foregoing work, exclusive of excavations for lock-chambers and approaches, is $255,901.34. Add to this for excavation as above, engineering and contingencies, 30 per cent., $76,770.40, and we have $332,671.74 as the entire cost of the work.

From this point to the Western and Atlantic Railroad Bridge no work is needed.

SECTION II.—FROM WESTERN AND ATLANTIC RAILROAD BRIDGE TO WEST POINT, GEORGIA.

This section is about 108 miles long, with an aggregate fall of 172 feet. Deduct from this 35.5 feet to be provided for by locks, and 1.2 feet represents the fall per mile, including shoals. Deduct the sum of the fall at these shoals, and we have an average of only .401 of a foot as the fall per mile over the balance of the river. The sum of the shoals is less than 10 miles in this section, there being 99 miles of good water that needs no improvement. The river bed here is very uniform, about 300 feet wide at the water surface, with high banks and bottom of rock. There are no sand-bars, snags, or other obstacles, except those named below, and the navigation may be permanently improved.

The first shoal is about 6 miles below the railroad bridge, and is known as

Greene and Pope's Shoal.—The river here is 250 feet wide, the shoal a succession of rock reefs, and 1,677 feet long, with a fall in that distance of 1.25 feet. The channel across these reefs needs deepening and widening. This can be done by the removal of 1,000 cubic yards of rock. Nine miles below this is

Austell's Shoal.—The river is 250 feet wide, with a fall of only 0.82 foot in 719 feet. The obstruction consists of narrow reefs, over which a channel should be excavated. The removal of 918 cubic yards of rock will do this. About 10 miles below Austell's is

"*Red Man's*" *Shoal.*—The river here widens from 300 feet to 500 feet, with a fall of 0.85 foot in 1,616 feet, the obstruction being similar to the two preceding shoals. The removeal of 150 cubic yards will give the required channel. About 7 miles below this is

Mcderis Shoal.—The river here varies from 500 feet to 600 feet wide. The shoal consists of narrow reefs, extending over 7,367 feet, with an aggregate fall of 8.42 feet. Between these reefs there are pools of deep water with a gentle current. A good channel may be secured by excavating a part of these reefs and the construction of three wing-dams, one below each of these obstacles. This would require 600 cubic yards of excavation and 750 cubic yards of wing-dam. Eight miles below this is

Jasper Sewell's Island.—The channel here is divided by Sewell's Island, the left hand being 100 feet and the right 200 feet wide. The best channel is in the right-hand channel. This shoal is 3,684 feet long, with a fall of 2.48 feet. The left-hand channel should be closed by a rubble-dam at the head of the island. The removal of 1,211 cubic yards of rock from the other channel will give the required depth. About 4 miles below this is

Bridge Shoal, at the crossing of the Griffin and North Alabama Railroad. The river here is 375 feet wide, the obstructions, consisting of some narrow reefs, extending over 300 feet and with a fall of 0.40 foot. The removal of 100 cubic yards of rock will give sufficient channel. Three miles below this is

Carter's Shoal.—A small island divides the channel here, which widens out from 300 to 400 feet, with a fall of 0.51 foot in 782 feet. The best water is found near the right, between the island and the shore. This channel is obstructed by some narrow reefs, and requires the removal of 100 cubic yards of rock. One mile below this is

"*Bull's Sluice*" *No.* 2.—This shoal consists of some narrow reefs. It is 287 feet long, with 1.70 feet fall. The removal of 222 cubic yards of rock from the best channel over these reefs will give the required depth. One mile below this is

Hemp's Shoal.—The river here is 575 feet wide, with 0.87 foot fall in 500 feet. The obstruction is caused by reefs with from 1 to 2 feet of water on them. The deepening and widening of the present channel is all that is needed. This can be accomplished by the removal of 100 cubic yards of rock. The next shoal is

McIntosh's.—The river here suddenly widens from 200 feet to 1,200 feet, with 7.24 feet fall in 3,790. At the upper end of the shoal it will be necessary to excavate a channel through the reef; 444 cubic yards of rock must be removed. The remainder of the shoal can be flooded by raising the dam at Hollingsworth's, 3 miles below.

Hollingsworth's Mill.—The river below the shoal is 400 feet wide, the shoal 750 feet long, with a fall of 3.51 feet. By raising the dam and closing it with a lock of 10 feet lift both shoals will be flooded. Three miles below is another

Shoal, name not known. The river here is from 500 feet to 700 feet wide, with 2.49 feet fall in 1,735 feet. The best water is near the right bank. The channel should be contracted by a wing-dam, extending from some exposed rocks in the river bed to the left bank and the widening of the passage through the reef. This will require 660 cubic yards of excavation, and 550 yards of wing-dam. One mile below this is

Hilley's Shoal.—The river here is 600 feet wide, with 1.45 feet fall in 590 feet. To give sufficient depth a wing-dam should be built below the reef and the channel above cleaned of projecting rocks. This requires 444 cubic yards of wing-dams. About one mile below this is another

Shoal, name unknown. The river here is from 600 feet to 700 feet wide, with 1.48 feet fall in 965 feet. The channel is divided by an island, the best water being in the left-hand channel. A rubble-dam, extending into the right-hand channel, should be

placed at the head of the island, so as to increase the flow of water in the left channel. This, with the removal of a small reef above the island, will give the needed navigation. Excavation required 100 cubic yards and 350 cubic yards for rubble-dam. One and a half miles below this is

Bushhead Shoal.—The river here is from 700 feet to 1,000 feet wide, with 5.17 feet fall in 2,120 feet. This shoal can be flooded by water from Daniel's Mill and needs no work. Two miles below this is

Daniel's Mill.—The river at the head of this shoal is 1,000 feet wide, and 300 feet just below it, with a fall of 8.85 feet in 5,334 feet. A dam closed by a lock of 11 feet lift will flood this shoal and Bushhead. Two miles below the mill is

Tompkins Shoal.—The river varies here from 300 feet to 800 feet, with 0.50 foot fall in 330 feet. The obstruction is trifling, and can be removed by excavating 67 cubic yards of rock. One mile below is

Franklin Shoal.—The river is 500 feet wide, with 0.80 foot fall in 2,014 feet. Some small islands divide the channel, but the best water will be found in mid-river. The removal of 355 cubic yards of rock will give the required depth. One mile below is another

Shoal, or rather reef, name not known. The river here is 700 feet wide, with 0.62 foot fall in 760 feet. The difficulty here is found in some narrow reefs through which the channel needs widening. The removal of 100 cubic yards of rock will do this. Five miles below this reef is

Jackson's Mill Shoal.—This is in reality two shoals about 1,200 feet apart, with deep water between them. The river at the upper shoal is about 830 feet wide; at the lower shoal about 700 feet. The fall at the upper shoal is 4.73 feet in 500 feet; at the lower shoal 1.96 feet in 1,304 feet. The greater fall was measured from the surface of the water in the old mill-dam at the head of the shoal. This would be very much reduced by taking away the dam. The improvements recommended here are, 1st. The opening of the channel through the old dam next to the right bank. 2d. The construction of a wing-dam below the shoal. 3d. The construction of a wing-dam at some point between the head and foot of shoal. These dams, it is believed, will regulate the current and give sufficient depth. At the lower shoal the river is divided by a small island into two channels. The closing of the left-hand channel by a riprap dam will be all that is needed here. This will require 322 cubic yards of rock excavation, 800 cubic yards wing-dam, and 150 yards riprap dam. Nine miles below Jackson's Mill is

Swanson's Shoal.—The river here is 700 feet wide, with a fall of 1.72 feet in 1,422 feet. The obstacle here is caused by reefs which require deepening in places 1 foot. To effect this the removal of 333 cubic yards of rock will be necessary. About 8 miles below Swanson's is

Boykin's Shoal.—The river is 900 feet wide, the channel being divided by small islands or tow heads. There is 0.87 foot fall in 495 feet. All that is needed here is the widening of the natural channel through the reef. This can be done by the removal of [illegible] cubic yards of rock. The next shoal, 4 miles below, is known as

Huguley's Shoal.—The river varies from 600 feet to 1,300 feet, the channel being divided by several small islands or tow heads. A dam, with a lock of 8 feet lift, is recommended as the necessary improvement here. One mile and a half below is

Pott's Shoal.—The fall is 5.06 feet in 3,635 feet, but as the channel is deep and straight it is believed that no serious difficulty will be experienced by boats passing it. The present channel should be cleaned and widened, and this will involve the removal of 309 cubic yards of rock. Five miles below is

West Point Shoals, near the town of West Point. The river here is 500 feet wide, with a fall of 1.78 feet in 2,955 feet. The obstructions here, like many that are called shoals on this part of the river, consist of narrow reefs with deep water between them. There being but little fall, the excavation of a passage-way sufficiently deep is all that is needed, and this generally can be effected by deepening the natural channel 1 foot. In the present instance the removal of 333 cubic yards and the construction of 300 yards of wing-dam below the shoal is all that is needed.

This completes the shoals and obstructions in the 2d Section, which you will find by—

Estimate sheet No. 2 will cost	$141,970 20
Add to this 20 per cent. for contingencies	28,394 04
and we have	170,364 24

as the cost of the proposed improvement.

SECTION III

embraces that portion of the Chattahoochee between West Point and Columbus, and is 33 miles long, with a measured fall of 318.31 feet. For about one-half this distance the water is of sufficient depth with a moderate current, there being deep and unobstructed pools from ½ mile to 4 miles. The river-bed in many places is very wide, dotted by numerous islands. Between these, narrow, and sometimes deep, channels

find their way. These channels over two of the longest shoals can be converted into commodious canals by constructing dams between the islands that form them, thus making a continuous channel or canal in which locks may be placed at proper intervals. There is an abundance of the best material at hand for the construction of such works as are needed. From West Point to what is known as

William Todd's Shoal, a distance of 3 miles, there is good water, with the exception of one narrow reef. Todd's Shoal is 650 feet long, with 2 feet at low-water in mid-channel, and requires deepening one foot. To do this, 1,444 cubic yards of rock must be removed. From this shoal to

Jack Todd's Shoal is about 1 mile, the water being good, with a gentle current. From the head of Jack Todd's Shoal to the reef below *Houston's Ferry* is 7¼ miles, with an aggregate fall of 51.31 feet. As the whole distance requires work of some description, it will be considered as one shoal. The river here varies from 600 feet to ¼ mile in width, the channel being divided by numerous islands. The banks are high and formed of rock, and so are the islands. From the head of the shoal to *Chattahoochee Factory* is 6,600 feet. The channel here follows the right bank, and is sufficiently deep, except at *Todd's Old Gin House*, where there is a reef with 1 foot at low-water. A channel should be excavated here 500 feet long and 2 feet deep; 2,400 feet below this is another reef 100 feet long, with 2 feet at low-water, but this will be flooded by the proposed dam at the factory. From this point to the factory it follows the right bank through the pond formed by the factory-dam. This dam is 200 feet long, and is nearly parallel with the shore, inclosing about ¼ of the water-surface of the river. It is proposed to raise this dam 2 feet, and extend it 600 feet by a dam 6 feet high, closing it by a lock at the factory 9.23 feet lift. For 3,600 feet below, the channel follows the right bank through a natural canal formed by islands. This channel is about 250 feet wide, and is sufficiently deep, except at two points. The first of these is about 1,000 feet below the factory, and consists of a reef 25 feet long and 2 feet deep. It needs deepening 1 foot by the removal of 55 cubic yards of rock. The second reef is 2,400 feet below the factory. This reef is 100 feet long, and 2 feet deep; the removal of 444 cubic yards will deepen it sufficiently. From the end of Island No. 3 to Turkey Island there is a shoal 1,000 feet long with 2 feet of water on it. It is proposed to construct a crib-dam from the upper end of Turkey Island to the head of this shoal—800 feet long and 6 feet high. When the dam at the factory is raised, this will flood the shoal to the required depth. From this reef to the *Georgia and Alabama Factory*—1,800 feet—there is a good channel formed by Turkey Island and Campbell's Island. This is about 200 feet wide. A dam 100 feet long connects these islands. This dam should be raised 2 feet. The dam at the factory should also be raised 2 feet, and closed by a lock of 14 feet lift.

For 2,400 feet below the factory there is a narrow channel formed by *Hodge's Island*. A channel must be excavated here 4 feet deep and 60 feet wide and 2,000 feet long, making 17,777 cubic yards of rock. From *Hodge's Island* the channel follows the right bank to the lower end of Johnson's Island, 13,000 feet. The channel here varies from 400 feet to 800 feet wide, with water sufficiently deep, except at the reefs named below. The first of these is 2,600 feet below Hodge's Island. This reef is about 100 feet long, 2.3 feet deep, and requires the removal of 155 cubic yards of rock. The next is 400 feet below this. It is 100 feet long, and requires an average deepening of 30 inches. The removal of 66 cubic yards of rock will do this. Eighteen hundred feet below this there is a succession of reefs with deep water between them, extending for 800 feet. The channel here should be deepened 1 foot, requiring the removal of 1,777 cubic yards of rock. Twenty-five hundred feet below this there is another reef, 100 feet long, 2 feet deep, and requires the removal of 222 cubic yards of rock to give it the necessary depth. Two thousand feet further there is another reef, 100 feet long, 1 foot deep, and requires the removal of 444 cubic yards of rock; 5,000 feet below this, a dam 670 feet long, with lock of 10 feet lift, will flood all the intervening reefs and give a good channel. This dam should be placed about 100 feet above *Houston's Ferry*.

Eight hundred feet below the ferry there is a reef 200 feet long and 1.5 feet deep. The removal of 666 cubic yards of rock will give the proper depth.

Below this reef there is good water for three miles. Here there is a fall of four feet in 1,000 feet. A wing-dam 800 feet long placed below this shoal will give sufficient depth.

At the head of *Hargett's Island* the right-hand channel should be closed by a dam 1,000 feet long and 6 feet high, so as to concentrate the water in the left-hand channel. At the lower end of Hargett's Island a dam 300 feet long, with a lock of 8 feet lift, will be needed. This island should be connected with *Cook's Island* by a dam 2,300 feet long and averaging 8 feet high. This would make a continuous canal behind these islands. A dam should be placed in this passage at the head of Cook's Island closed by a lock 2.70 feet lift. From this point the route passes between Cook's Island and the left bank. Two thousand and four hundred feet below the first dam there should be another dam 300 feet long, with lock of 10 feet lift. Two thousand and eight hundred feet below this there should be another dam 200 feet long, with lock of 10 feet lift. Two thou-

sand and two hundred feet below this, a dam 100 feet long connecting *Round Island* with the shore, with lock of 10 feet lift.

Cook's Island should be connected with *Round Island* by a dam 300 feet long and 10 feet high. Nine hundred feet below Round Island there is a small wooded island. This should be connected with Round Island by a dam 6 feet high. Just below the head of this island a dam 200 feet long, with lock of 8.30 feet lift, will be needed.

For 1,000 feet below this lock there is a good channel 100 feet wide, which extends to the end of the island. The route then enters the river, which is 1,300 feet wide; 4,[illegible] feet below this it suddenly contracts to 600 feet, with a fall of 15 feet in this distance. Here a dam 600 feet long, with a lock of 15 feet lift, will be required. Thirty-five hundred feet below this a dam 700 feet long, with lock of 16 feet lift, will be needed. This will pond the water to *Bull's Sluice No.* 3, giving sufficient depth. For 5,200 feet the river now is 1,100 feet wide, with 10 feet fall. A dam 1,400 feet long, with a lock of 1[illegible] feet lift, will pond this. From this point for a half mile there is good water. Here *Tate's Shoals* begin. The river varies from 700 feet to 600 feet in width. Thirty-[illegible] hundred feet from the head of the shoal the fall is 10 feet, and here a dam must be placed 1,400 feet long, with lock of 10 feet lift. Eighteen hundred feet below this a second dam 1,000 feet long, with a lock of 12 feet lift, will be required. These two dams will pond this shoal, which has a fall of 22 feet in about a mile. From this for about one mile there is good water to *Mulberry Creek Shoal*. The river here is 1,[illegible] feet, with a fall of 30 feet in two miles. This shoal will require two dams, each 1,000 feet long, with locks of 15 feet lift. There is good water now for four miles with the exception of one reef about 50 feet long, which has about two feet water on it; 222 cubic yards of excavation will give the sufficient depth. The next shoal is

"Standing Boy."—This is a reef 1,000 feet long, with 2 feet water on it. The removal of 2,000 cubic yards of rock will give the proper depth. The river here is 1,400 feet wide. From "Standing Boy" to Columbus Shoal, or, as it is more commonly called, *Coweta Falls*, there is about ¼ mile of good water. Here, in a distance of 12,800 feet, we have a fall of 80 feet. Thirty-six hundred feet from the head of the shoal a dam 2,000 feet long, with lock of 16 feet lift, should be placed. Below this dam the river is 1,800 feet wide, the channel being divided by large rock islands. The best channel will be found near the right bank; 1,200 feet below the first dam a second dam should be built, 400 feet long, with lock of 16-feet lift. This dam is to be connected with the first fall by a wing-dam 1,000 feet long and 14 feet high; 3,000 feet below this a third dam will be necessary. This dam will be 1,560 feet long, with lock of 16 feet lift; 1,600 feet from this the fourth dam should be located. This dam will be 600 feet long, with lock of 16 feet lift; 3,500 feet from this a dam 600 feet long, with lock of 16 feet lift, will complete the work. Four thousand two hundred feet below the third dam there is a mill-dam. A lock of 7 feet lift should be placed in this dam. Three thousand seven hundred feet from this is the dam of the

Eagle and Phœnix Manufacturing Company.—A lock should be built in this of 16 feet lift. Sixteen hundred feet below the factory-dam another dam will be needed to [illegible] the end of the shoal; the lock here would have a lift of 16 feet.

This brings us to the head of navigation, the surface of the water being 239 feet above tide, according to the data furnished me by Col. L. P. Grant, chief engineer and general superintendent of the Western Railroad.

You will find by estimate sheet No. 3, herewith submitted, that the cost of the work completed, with dams and locks of the size and character described in this report, and a channel 60 feet wide and 3 feet deep at extreme low-water, will be	$635,5[illegible]
Engineering and contingencies, 30 per cent. added	190,6[illegible]
Making a total of	826,22[illegible]

No estimates could be made for excavating lock chambers and approaches, and the per cent. for contingencies was therefore largely increased.

We have for improving the 1st section, cost	$332,671 [illegible]
We have for improving the 2d section, cost	170,364 [illegible]
We have for improving the 3d section, cost	826,22[illegible]
Total	1,329,26[illegible]

When we consider the number of people to be benefited by this improvement and the important interests that will be served by opening the river, the amount seems insignificant compared with the results to be obtained.

The accompanying maps, plans, and tabular statements will furnish you the necessary details.

My thanks are due to the persons employed in the field, including Mr. R. M. Clayton, Mr. Henry L. Collier, and Mr. Horace Bradley.

Very respectfully, your obedient servant,

B. W. FROBEL,
Assistant Engineer.

Maj. W. R. KING,
Corps of Engineers.

ESTIMATES.

Chattahoochee survey, section 1, from Thompson's Bridge to Western and Atlantic Railroad Bridge.

	Name of shoal.	Channel excavation (cubic yards).	Price per yard.	Canal excavation (cubic yards).	Price per yard.	Timber (feet, B. M.).	Price per 1,000.	Cubic yards stone in cribs.	Price per yard.	Lock. No.	Lock. Lift (feet)	Cost of lock.	Total cost.	Distance from Thompson's.
1	Shallow Ford					70, 668	$15 00	1, 466	$1 00	1	10	$11, 000 00	$13, 526 02	3
2	Johnson's			400	$3 00								1, 200 00	3½
3	Mooney's	444	$5 00										2, 220 00	4½
4	Overby's					42, 720	15 00	740	1 00	2	7	7, 700 00	9, 080 80	8
5	Brown's Mill									3	7	7, 700 00	7, 700 00	10
6	Below Brown's					67, 632	15 00	963	1 00	4	10	11, 000 00	12, 977 48	13
7	Pirkles	340	5 00										1, 700 00	21
8	Winding Shoals and Garner's Bridge					147, 168	15 00	3, 318	1 00	5	16	15, 400 00	20, 925 52	23
9	Mathews's Fish Dam	88	5 00										440 00	27
10	Jones's Shoal	2, 621	5 00										13, 105 00	39
11	Island Shoal					129, 480	15 00	2, 666	1 00	6	9	9, 900 00	14, 508 20	49
12	Near Kelpen's					213, 600	15 00	4, 355	1 00	7	12	13, 200 00	20, 759 00	53
13	Bull's Sluice					118, 920	15 00	2, 453	1 00	8	10	11, 000 00	15, 236 80	61
14	Below Bull's Sluice					293, 880	15 00	7, 800	1 00	9	15	16, 500 00	28, 708 20	62
15	Lower end Bull's Sluice					226, 080	15 00	6, 000	1 00	10	15	16, 500 00	25, 891 20	63
16	Devil's Race Course					231, 336	15 00	4, 718	1 00	11	12	13, 200 00	21, 388 04	64
17	Lower end Devil's Race Course					205, 272	15 00	4, 741	1 00	12	13. 5	14, 850 00	22, 670 08	65
18	Dimsey's Ferry					77, 520	15 00	1, 600	1 00	13	10	11, 000 00	13, 762 80	66½
19	Pace's Ferry					64, 080	15 00	1, 111	1 00	14	6. 5	7, 150 00	9, 220 20	69
20	Buzzard's Roost	88	5 00										440 00	71
21	De Four's Ferry	88	5 00										440 00	73
	Total	3, 669		400		1, 888, 356		41, 931				166, 100 00	255, 901 34	

Chattahoochee River survey, section 2, from Western and Atlantic Railroad Bridge to West Point, Georgia.

		Solid rock excavation.	Price per yard.	Wing-dam.	Price per yard.	Riprap-dam.	Price per yard.	Timber.	Price per M.	Stone in cribs.	Price per yard.	Iron.	Price per pound.	Locks.		Cost of lock.	Total cost.
														Number.	Lift.		
		Cu. yds.		Cu. yds.		Cu. yds.		Ft., B. M.		Cu. yds.		Lbs.			Feet.		
1	Greene & Pope's	1,000	$5 00														$5,000 00
2	Anstell's	918	5 00														4,590 00
3	"Red Man"	150	5 00														750 00
4	Mederis	600	5 00	750	$2 00												4,500 00
5	Island	1,211	5 00	125	1 50												6,242 50
6	Griffin and North Alabama Railway Bridge	100	5 00														500 00
7	Carter's	100	5 00														500 00
8	Bull's Sluice No. 2	222	5 00														1,110 00
9	Hemp's	100	5 00														500 00
10	McIntosh	444	5 00														a2,220 00
11	Hollingsworth							211,980	$15 00	3,253	$1 00	1,540	$0 06	1	10	$15,000 00	21,525 10
12	Three miles below Hollingsworth	660	5 00	550	1 50												4,125 00
13	Hilley's	444	5 00	200	1 50												2,520 00
14	One and a half miles above Bush Head	100	5 00	350	3 00												1,550 00
15	Bush Head																(b)
16	Daniel's Mill	400	5 00					399,684	15 00	6,135	1 00	2,905	06	2	11	$15,000 00	29,304 56
17	Tompkin's	67	5 00														335 00
18	Franklin	355	5 00														1,775 00
19	Below Franklin	100	5 00														500 00
20	Jackson's Mill	322	5 00	800	3 00	150	$0 50										4,085 00
21	Swanson's	333	5 00														1,665 00
22	Boykin	133	5 00														665 00
23	Crowder & Harrolson							66,666	15 00					3	6	12,000 00	13,000 00
24	Huguley & Ferrell							243,264	15 00	3,733	1 00	1,768	06	4	8½	12,000 00	19,488 04
25	Pott's	309	5 00														1,545 00
26	West Point	333	5 00	300	1 50												2,115 00
	Allowance for ledges that were not surveyed	2,372	5 00														11,860 00
	Total	10,773		3,075		150		921,594		13,121		6,213				54,000 00	141,970 20

NOTE.—*a* and *b* to be flooded by backwater; *a* from Hollingsworth Mill, *b* from Daniel's Mill.

Chattahoochee survey, section 3, from West Point, Ga., to Columbus, Ga.

	Name of shoal.	Channel excavation.	Price per yard.	Canal excavation.	Sheet.	Price per yard.	Timber.	Price per 1,000.	Stone in cribs.	Price per yard.	Locks. Number.	Locks. Lift.	Cost of locks.	Total cost.	Distance from West Point.
		Cu. yds.		Cu. yds.			Feet, B. M.		Cu. yds.			Feet.			
1	William Todd's	1,444	$5 00		1									$7,220 00	3
2	Jack Todd's	2,222	5 00		1									11,110 00	3½
3	Chattahoochee Factory				1		168,288	$15 00	1,689	$1 00	1	9.2	$10,120 00	14,333 32	4
4	Shoals at Stations O and R	499	5 00		1									2,495 00	5
5	Alabama and Georgia Factory			17,777	1	$1 00	111,960	15 00	1,097	1 00	2	14	15,000 00	35,553 40	7
6	Shoals from F to Q	2,664	5 00		1									13,320 00	
7	Above Houston's Ferry	666	5 00		1		214,992	15 00	5,081	1 00	3	10	11,000 00	22,635 88	12
8	Hargett's Island				2		197,616	15 00	2,444	1 00	4	8	8,800 00	14,208 24	15
9	Upper end Cook's Island				2		428,568	15 00	6,178	1 00	5	12.7	13,970 00	26,576 52	16
10	Cook's Island				2		25,056	15 00	533	1 00	6	10	11,000 00	11,908 84	16½
11	......do				2		50,112	15 00	1,066	1 00	7	10	11,000 00	12,817 68	
12	Round Island				2		65,136	15 00	933	1 00	8	10	11,000 00	12,910 04	17
13	Above Hundley's old ferry				2		169,352	15 00	2,266	1 00	9	8½	9,020 80	13,826 28	18
14	Bull's Sluice No. 3				2		306,720	15 00	8,888	1 00	10	15	16,500 00	29,988 80	18½
15	Bull's Sluice No. 4				2		357,840	15 00	11,407	1 00	11	16	17,600 00	34,374 60	19
16	Station U below Bull's Sluice				2		306,336	15 00	7,259	1 00	12	10	11,000 00	22,854 04	
17	Tate's				2		298,752	15 00	5,185	1 00	13	12	13,200 00	22,866 28	21
18	......do				2		306,336	15 00	7,259	1 00	14	12	13,200 00	25,054 04	
19	Above mouth of Mulberry				2		1,000 000	15 00	20,000	1 00	15 & 16	15 each	33,000 00	68,000 00	
20	Standing Boy	2,222	5 00		2									11,110 00	28
21	Clapp's Factory				3		777,984	15 00	15,850	1 00	17 & 18	16 each	35,200 00	62,719 76	30
22	Below Clapp's Factory				3		578,040	15 00	14,488	1 00	19	16	17,600 00	40,758 60	
23	Station V				3		237,600	15 00	5,088	1 00	20	16	17,600 00	26,852 00	
24	Station C				3		306,720	15 00	8,888	1 00	21	16	17,600 00	31,088 80	
25	Flour Mill				3						22	7	7,700 00	7,700 00	32
26	Eagle's and Phenix Dam				3						23	16	17,600 00	17,600 00	
27	Head of navigation				3		415,296	15 00	11,852	1 00	24	16	17,600 00	35,681 44	33
	Total	9,717		17,777			6,322,704		138,051				336,310 00	635,563 56	

Showing oscillations of Chattahoochee River, velocity of currents, volume of water, and height of bridges above ordinary water surface, from Thompson's Bridge to head of navigation, Columbus, Ga.

Distance in miles, approximate.	Name of points.	Low-water above tide.	High-water above tide.	Difference.	Volume of water.	Velocity of current.	Fall from Thompson's Bridge.	Height of railroad bridges.	Toll bridges.	Remarks.
					Cu. ft. per second.	*Miles per hour.*	*Feet.*	*Feet.*	*Feet.*	
......	Gainesville	....	....	....	....	....	....	....	....	1,222 feet above tide by railroad survey.
......	Thompson's Bridge	989.02	1,013.02	24.00	....	$3\frac{1}{2}$	....	....	29.65	At 14 feet above low-water.
......	Shallow Ford	982.10	....	....	929.00	....	6.92	....	....	At crossing measured by C. A. Locke, C. E.
9	Mouth of Chestatee	963.48	....	....	1,240.00	....	25.54	....	....	Taken below mouth of Chestatee.
$11\frac{1}{2}$	Brown's Mill Dam	961.50	974.50	13.00	....	....	27.52	....	23.00	Above dam.
$11\frac{1}{2}$	......do	954.41	....	27.09	....	....	34.61	....	....	Below dam.
21	Garner's Bridge	*915.01	932.17	17.16	....	$4\frac{1}{2}$	74.00	....	22.50	
......	Little's Ferry	904.25	....	....	....	....	84.77	....	....	Tested on railroad at Suwanee.
56	Roswell Bridge	862.02	873.02	11.00	....	$2\frac{9}{16}$	127.00	....	....	At $\frac{4}{10}$ above low-water.
73	Western and Atlantic Railroad Bridge.	762.02	....	....	....	....	227.00	57.71	....	Railroad survey.
91	Austell's Shoals	....	....	....	2,000.00	....	....	72.50	....	Estimated at low spring tide.
......	Georgia and North Alabama Railroad Bridge.	....	....	....	....	....	....	....	....	
......	Daniels' Mill Dam	....	....	16.81	....	....	....	....	....	
......	Franklin Bridge	....	....	....	....	....	....	....	20.00	
......	Jackson's Dam	....	....	15.41	....	....	....	....	18.00	
......	Chattahoochee Bridge	....	....	....	....	....	....	....	....	
......	Crowder & Harrolson's Dam	....	....	13.89	....	....	....	....	....	
181	Atlanta and West Point Railroad Bridge.	594.00	619.60	25.60	....	....	389.00	19.70	....	As determined by railroad surveys.
215	Columbus, Ga.	238.00	280.00	42.00	3,000.00	....	751.02	....	....	Supposed elevation of Columbus. Distance estimated by land lots and actual measurement.

* Assumed.

REPORT OF MR. D. L. SUBLETT, ASSISTANT ENGINEER.

ATLANTA, GA., *June* 23, 1879.

SIR: I have the honor to submit herewith my report on the examination and survey of the Chattahoochee River, from Thompson's Bridge, five miles from Gainesville, Hall County, to Columbus, Ga., the present head of steamboat navigation.

In obedience to orders received from Maj. W. R. King, United States Corps of Engineers, I left Chattanooga, Tenn., December 26, 1878, for Atlanta, and reported to you the same day, and at once proceeded, under your directions, to prepare the necessary outfit and organize a party. * * *

Estimates were required to be made on the basis of a 60-foot channel and 3 feet at low-water.

My instructions directed that soundings be taken the entire route, and wherever obstructions occurred a line tagged at every 20 feet was to be stretched and soundings taken every 100 feet or less, as the nature of the obstructions required. I was also directed to measure the velocity of the current at each shoal, ascertain the volume of water at favorable points, and, when practicable, make geological sections. * * *

Owing to the unprecedented cold weather for this climate, and the river being frozen over, active field operations were not begun until January 8, except to transfer the levels from the depot at Gainesville to Thompson's Bridge, starting with an elevation of 1,222 feet above tide-water, as determined by the railroad survey for this point.

Low-water at Thompson's Bridge was ascertained to be 989.02 feet above tide.

Several of the railroads entering Atlanta either cross or approach near the Chattahoochee, and as their profiles are all based on the elevation of Atlanta, which is 1,050 feet, this furnished a convenient means of ascertaining the inclination of the river between the limits of this survey, as well as other important points along the route. The distances were obtained by actual measurements and by land lots, and are believed to be approximately correct. The survey was begun at an unfavorable season to procure accurate data, owing to frequent rises this time of the year. On the breaking up of the freeze the river rose 14 feet in twelve hours at Thompson's Bridge, and fell in twenty-four hours sufficient to admit of beginning the survey. * * *

The survey reached West Point, 108 miles from the Western and Atlantic Railroad Bridge, by April 10, and from thence was pushed on to Columbus. * * *

Between these points it was not of such a detailed nature as to admit of making accurate estimates, but was conducted more with a view to aid in future examinations. * * *

The survey having been completed to the head of steamboat navigation at Columbus, I returned with my party to Atlanta on the 6th of May.

GENERAL DESCRIPTION.

From Thompson's Bridge, where the survey began, the Chattahoochee flows in a general southwest course along a narrow valley that marks the metamorphic formation, until, reaching West Point, it turns a little southeast and forces a passage through the Chattahoochee Ridge at Pine Mountain, and by a continuous series of rapid falls over granite ledges it enters the Post-tertiary formation at Columbus, the present head of steamboat navigation, and is then navigable for 400 miles to Apalachicola for steamers of 130 feet length, 35 feet width, drawing from 2½ to 3 feet of water, with a capacity of from 450 to 750 bales of cotton. The topographical features do not greatly vary from Thompson's to West Point, and present remarkably favorable features to permanent improvement. Where no obstructions occur the river presents a beautiful appearance, a gentle current, banks uniform and high, well protected by aquatic trees, such as willow, reed, birch, &c. Wherever the hills recede from the river they give place to bottom lands which are in a high state of cultivation; when the hills approach on one side or both, they generally bring bars and ledges composed of granite, gneiss, quartzite, dolorite, and other stones, which, barring the passage of the water, the river cuts out a channel on the weaker side, widening its bed and reducing the depth of water. As soon as the obstructions are overcome the river assumes its natural width. The water is generally sufficiently deep above and below the bars or ledges. Where these obstructions occur many islands are sometimes formed, with several channels; these islands vary in size from the small "tow-head" to 700 or 800 acres, and are frequently covered with original forest, and generally present favorable features for improvement. Sometimes the river is hill-bound on both sides with perpendicular rock cliffs, as is the case between Roswell and Atlanta, and the fall is very great, current rapid, and channel filled with projecting rock, and the river alternately expands and contracts to unusual dimensions. From Thompson's Bridge to Western and Atlantic Railroad Bridge, a distance of 73 miles, there is a fall of 227 feet. There is in this distance about 35 miles of good water, free from obstructions, varying in depth from 2½ to 10 feet; at low-water, width of river from 200 to 350 feet.*

*From Thompson's to a point opposite Sewanee there is more or less interfering rock, even where the water is deep, as the bed of the river is composed of an irregular granite bottom with projecting points approaching near the surface. From Roswell to the Western and Atlantic Railroad Bridge, a distance of 17½ miles, the fall is 100 feet.

On reaching the Western and Atlantic Railroad Bridge the hills disappear, and give place to wide, fertile bottoms; the river has a uniform width of 250 to 300 feet, with moderately rapid current, and no very serious obstacles until reaching Campbellton, a distance of 22 miles.

Ledges cross the river at every few miles, but from 2 to 3 feet water can generally be obtained; the banks are high, even, and well protected, and there is only one island. After leaving Campbellton the country becomes more broken, and after passing Coweta County line, a distance of about 43 miles from the Western and Atlantic Railroad Bridge, shoals become frequent, and to West Point there are numerous islands and channels, and many streams enter, greatly increasing the volume of water, which was ascertained to be approximately 3,000 cubic feet per mile at ordinary low-water in Heard County land lot 344.

In Troup and Heard counties there are 4 mill-dams, 3 of which entirely cross the river, with lifts of 3 to 7 feet, some of which can be utilized in improving the river. From Iceville to West Point, a distance of 108 miles, the fall is 162 feet, or about 1½ feet per mile; the greatest fall being in Heard and Troup counties, where the country is much broken. There is one mill-dam (Brown's) in Hall County, of 7 feet lift.

Five miles below West Point, at the Chattahoochee Cotton Mills, there is a dam partially across the river, and about 3 miles below this factory is the Georgia and Alabama Cotton Factory, and two dams across the right channel, formed by Turkey and Campbell's islands. From this point to Columbus there is a series of continued and rapid falls; the river is a mass of projecting rock, with hundreds of islands and channels, and varying in width from a quarter to a mile wide; the fall averages 11 feet per mile, and is 362 feet in 34 miles; the river sometimes contracts to unusual dimensions, and is then inclosed by solid rock walls; near Clapp's Factory, in a distance of a quarter of a mile, it contracts from a width of half a mile to 90 feet; the entire volume of water passes through this space for one-half mile, and has a fall of 25 feet in 300 feet, and about 120 feet in five miles.

I do not consider that this section of the river can be improved to advantage. Owing, as has been said, to the limited amount of available funds, the survey was not of such a nature as to recommend any expenditure on this portion of the river, except as far as the Chattahoochee Factory, 5 miles below West Point.

From Thompson's to West Point the river flows over a solid rock bed; there is almost an entire absence of sand and gravel bars; timber and stone are everywhere abundant. Within the limits of this survey the Chattahoochee flows through fifteen of the most productive counties in Georgia, which, with the counties in Alabama adjoining the river, gives an aggregate population of over 300,000 persons directly interested in the opening of the river above West Point.

The following is a statement of agricultural and other resources of the country through which the Chattahoochee flows, with the acreage of improved and unimproved lands, with their value, taken from the last census reports and from the State auditor's report for 1877:

Number of acres of improved land	2,852,[illegible]
Value of acres of improved land	$14,429,5[illegible]
Number of acres of unimproved land	252,7[illegible]
Value of acres of unimproved land	$112,1[illegible]
Capital invested in cotton factories	$1,760,7[illegible]
Aggregate value of all property	$49,622,1[illegible]

There are 12 cotton factories, with 80,000 spindles; 242 grain-mills, 134 saw-mills, 1 foundry, 21 tanneries, 9 carding machines, 1 pottery, mostly situated on the Chattahoochee or its tributaries. The unimproved lands consist mostly of original forest of choice timber. This does not include the counties in Alabama on the line of the Chattahoochee.

Agricultural productions, as shown by the census report of 1870, is as follows, viz:

Value of all farm products	$9,612,[illegible]
Value of live stock	$3,645,1[illegible]
Number of bushels of wheat	443,[illegible]
Number of bushels of corn	2,368,5[illegible]
Number of bushels of oats	250,[illegible]
Bales of cotton	85,0[illegible]
Pounds of wool	64,[illegible]
Bushels of Irish potatoes	2[illegible],[illegible]
Bushels of sweet potatoes	325,[illegible]
Pounds of butter	744,0[illegible]

GEOLOGICAL AND MINERAL RESOURCES.

Its geological features are entirely metamorphic; granite, gneiss, mica, schist, trap and flexible sandstone are the principal rocks. Gold, asbestos, copper, mica, graph-

ite, iron ore, and other valuable minerals abound. Gold is extensively mined, and a large amount of capital is invested in this industry. Asbestos and copper are also mined. Timber consists of white oak, hickory, chestnut, poplar, long-leaf pine, and many other varieties, and the supply is almost inexhaustible, especially of the latter. At most of the shoals, especially above Atlanta, gold is washed in the dull season by the farmers, who realize from $1 to $2 per day by the pan process.

PLAN OF IMPROVEMENT.

The improvement will consist in excavating a channel through the ledges and bars and removal of isolated and projecting rocks that interfere with navigation, and the building of jetty-dams, to contract the channel to its normal width where it has widened, and the erection of locks and dams where the fall is too great to be overcome by open-channel navigation.

Estimates are made for crib-dams with width equal to height; locks 150 by 35 feet. Estimates are made for part masonry and part crib-work. The accompanying maps and tables will show the location and estimated cost at each shoal.

The following table, No. 1, shows the oscillations of the river from Thompson's to Columbus, velocity of current, volume of water, and height of bridges above low-water at important points. Owing to the fact that the Chattahoochee is fed entirely by living streams, the difference between summer and winter low-tide does not greatly vary. The valley drained by the Chattahoochee averages about 70 miles wide, and the fall is about 10 feet per mile. The streams entering it are short, and, flowing from living springs, furnish unlimited power, which the people are not slow to utilize where an access to market can be obtained. It is believed that the opening of the river above West Point will give a great impetus to the building of cotton factories, which has already added so much to the prosperity and wealth of West Point and Columbus. The people along this section are urgent in their demands to have the river opened to navigation. The future, with a more careful survey, will determine as regards the river below West Point. The nature of the river bed, the absence of sand and gravel bars to any great extent, the solid character of its banks, and with no large tributaries to bring down drift, and being free from ice in winter, are important features as regards the permanency of the improvement. Owing to the solid nature of the river bed, the cost of foundations will be greatly reduced, and this item of cost can frequently be entirely dispensed with; also aprons for wing and jetty dams, as experience has shown that fish-dams built of loose stones gathered from the adjacent farms have stood intact for many years. The stone varies in degrees of hardness from a close-textured granite to a coarse micaceous gneiss; owing to its frequent shelving nature, can generally be easily removed. Much of the stone is loose rock fallen from the adjacent bluffs. The water is sufficiently deep in many places to allow the rock to remain in the river after being broken off. Bateaux carrying 70 bales of cotton have been run from Franklin to West Point; no other boats have ever navigated this river above Columbus. The section of the river between Thompson's and Atlanta, a distance of 73 miles, will require the construction of 12 locks and dams, with an average lift of 12 feet, seven of which will be between Atlanta and Roswell. The section from Iceville or Western and Atlantic Railroad Bridge to West Point, a distance of 108 miles, can be economically and permanently improved at a very moderate cost compared with the benefits that will result, and will open up a very large section now entirely cut off from market facilities. Many of the farmers, being unable to procure a market for their grain production, have been engaged in illicit distilling, and the expense to the government in putting down this nefarious traffic would go far towards improving the river and making good citizens of those who are now engaged in violating the laws. Four locks and dams will be required on this portion of the river, but two of the dams already constructed can be utilized by slight repairs and the cost greatly lessened. In conclusion, I would state that I think it will be necessary to have a channel at least 100 feet wide. Estimates having been made under your directions, none accompany this report.

Very respectfully, your obedient servant,

D. L. SUBLETT,
Assistant Engineer.

Mr. B. W. FROBEL,
Assistant Engineer.

APPENDIX W.

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF OHIO RIVER—SUPERINTENDENCE AND MANAGEMENT OF THE LOUISVILLE AND PORTLAND CANAL.

REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, BVT. MAJ. GEN. U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 13, 1880.

GENERAL: I have the honor to transmit herewith the annual reports relating to the river and harbor improvements under my charge, for the fiscal year ending June 30, 1880.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

W 1.

IMPROVEMENT OF THE FALLS OF THE OHIO RIVER.

The past year was quite favorable for the prosecution of this work, and a great deal of useful work was done.

The water became low in July, and then again in September, and remained so until November 17, 1879.

All the fixed portions of the dam at the head of the falls were completed, and the portions of it and of the apron-dam at the head of the canal, which had been previously built, placed in complete repair. The foundation and abutments for the movable dam in the middle chute were completed, the boat for the storage of wickets, &c., was built, the movable dam itself was set up, fitted, and nearly completed at the canal-shops, and considerable work was done in blasting out dangerous obstructions in the Indiana Chute.

The opening left in the cross-dam at the head of the falls in the Indiana Chute is 600 feet long. The length of this dam from this opening to the Indiana shore is 210 feet, and to the apron-dam at the head of the canal on the Kentucky side is 2,532 feet. The opening in the middle chute, in which the movable dam will be placed, is 300 feet long.

The original estimate for this work was $1,243,500. There has been allotted and appropriated for it as follows:

1868, allotted	$85,000
1869, allotted	178,500
1870, appropriated	450,000
1871, appropriated	250,000
1872, appropriated	300,000
1873, appropriated	100,000
1875, appropriated	100,000
Total	1,463,500

Of this amount $1,448,838.50 has been expended.

The reasons for the exceeding of the original estimate for this work have been given in previous reports.

During the present year, if the stages of water will permit, it is proposed to place the movable dam in position, and with whatever funds remain on hand to continue the removal of some of the worst obstructions in the Indiana Chute.

A thorough improvement of this chute would require the removal of about 26,000 cubic yards of rock, at a probable cost of $110,000.

Mr. Philip J. Schopp, assistant engineer, has been in local charge of the work since the death of Capt. A. N. Lee, Corps of Engineers, October 31, 1879.

The work is located in the third collection district of Kentucky. The nearest port of entry is Louisville, Ky.

The amount of revenue collected at this port during the fiscal year was $60,12[illegible].

The commerce and navigation of the Mississippi River and all its branches will be benefited by the completion of this work.

Money statement.

July 1, 1879, amount available	$43,6[illegible]
July 1, 1880, amount expended during fiscal year	29,34[illegible]
July 1, 1880, amount available	14,3[illegible]

W 2.

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL.

During the past year the canal was open two hundred and ninety-one days. It was closed sixteen days for repairs and fifty-seven days by high-water.

The receipts during the year amounted to $55,588.22, and the expenditures to $77,106.53. Of the latter the sum of $44,292.61 was expended on superintendence, management, and ordinary repair, and $32,003.07 on permanent repairs. The cash on hand July 1, 1880, was $29,496.6[illegible]

By act of Congress approved May 18, 1880, this canal was made free from tolls after midnight July 1, 1880.

By a clause in the river and harbor act approved June 14, 1880, the balance on hand, after payment of any existing liabilities, collected heretofore as tolls on the Louisville and Portland Canal, or which may hereafter be so collected prior to the passage of an act to make said canal free to the public, is hereby authorized to be expended for its improvement, provided such expenditure shall not exceed $60,000.

I presume that this means that all of the money on hand at midnight on July 1, 1880, after payment of any existing liability, if not in excess of $60,000, may be expended on the improvement of the canal.

I will therefore place the balance on hand at midnight June 30, 1880, *i. e.*, $29,496.65, together with the tolls that may be collected on July 1, 1880, to the credit of the improvement of the canal.

The law makes no provision for the moneys derived from the four other sources of revenue; *i. e.*, use of dry-dock, towing, dredging, and use of steam-pump.

I will, therefore, until further orders, simply deposit these sums to the credit of the canal, but not expend them until I receive further instructions.

A great deal of useful and important work was done on the canal during the year, as the large sum ($32,003.07) expended on permanent repairs indicates.

Five additional engines for operating the gates were purchased and are now being placed in position; extensive progress has been made in the reconstruction of the middle gates; the grading, paving, and sodding of the slopes on the sides of the locks completed; new winding machinery attached to the upper gates; the change made in the old locks from three to two chambers and the new gates therefor have been completed; and numerous slight repairs made on the lock machinery and the plant for operating the canal.

During the present year it is intended, under authority already granted, to complete the reconstruction of the middle gates of the new locks, to rebuild the lower gates, to reconstruct the suspension apparatus for all the gates, to place the remaining engines for operating the gates in position, to construct new gates for dry-dock, and build a new hull for dredge No. 1.

The estimated cost of these permanent repairs is about $21,000.

The middle gates are both operated by engines. The latter open them in 3½ minutes, when it formerly required from 15 to 20 minutes. As soon as all the engines are in place a reduction of ten lock-hands will be made.

It is estimated that the expenditure for operating and keeping the canal in ordinary repair will be about $42,000, which, under the law, must now be drawn from the Treasury.

After the permanent repairs contemplated during the present year are made, there will still remain a balance of the amount collected from tolls and placed to the credit of the canal.

It is proposed to expend this sum during the fiscal year ending June 30, 1882, in building new upper gates for the new locks, for permanent engine houses at the locks, and for new upper gates at the old locks.

It is estimated that the sum necessary for operating and keeping the canal in ordinary repair during the fiscal year ending June 30, 1882, will be about $40,500.

Besides the miscellaneous freight on passenger and freight boats, there passed through the canal during the year 13,592,000 bushels of coal, 120,332 barrels of salt, and 36,305 tons of iron ore.

The total receipts on this canal from June 11, 1874, to June 30, 1880, during which period the government has had charge of it, amount to $416,310.67, and the expenditures to $386,814.02, leaving the balance of $29,496.65.

The expenditures include about $120,000 for permanent repairs.

In conclusion, I desire to commend Mr. Philip J. Schopp, who is in local charge of the work, and his assistants for the faithful manner in which they have conducted the work.

Financial statement for fiscal year ending June 30, 1880.

Deposits.		Expenditures.	
Months.	Amounts.	Months.	Amounts.
1879.		1879.	
July	$3, 097 70	July	$7, 282 [illegible]
August	5, 636 16	August	496 [illegible]
September	3, 888 49	September	7, 368 [illegible]
October	726 52	October	8, 897 [illegible]
November	4, 063 74	November	18, 646 [illegible]
December	7, 817 03	December	9, 972 [illegible]
1880.		1880.	
January	4, 722 66	January	....
February	4, 279 51	February	7, 536 [illegible]
March	3, 767 42	March	578 [illegible]
April	5, 525 50	April	7, 861 [illegible]
May	4, 227 39	May	3, 975 [illegible]
June	7, 836 10	June	4, 469 [illegible]
Total	55, 588 22	Total	77, 106 [illegible]

Cash on hand June 30, 1880, $29,496.65.

Financial statement for fiscal year ending June 30, 1880.

Receipts.		Expenses.	
How derived.	Amount.	How expended.	Amount.
Tolls	$55, 081 97	Lockage department	$30, 670 [illegible]
Rents	166 25	Dredge department	13, 622 [illegible]
Dry-dock	172 50	Improvements	32, 813 [illegible]
Towage	107 50		
Dredging	60 00		
Total	55, 588 22	Total	77, 106 [illegible]

Detailed statement of expenditures for superintendence, management, and repairs Louisville and Portland Canal for the fiscal year ending June 30, 1880.

Date.	Lockage department. Labor.	Lockage department. Purchases and repairs.	Lockage department. Total.	Dredge department. Labor.	Dredge department. Purchases and repairs.	Dredge department. Total.	Improvements.	Grand total.
1879.								
July	$2, 325 00	$353 22	$2, 678 22	$835 00	$1, 057 24	$1, 892 24	$3, 209 34	$7, 779 [illegible]
August	2, 325 00	125 28	2, 450 28	899 65	290 24	1, 189 89	6, 431 60	10, 67[illegible]
September	2, 325 00	230 68	2, 555 68	835 00	134 78	969 78	2, 688 48	6, 213 [illegible]
October	2, 325 00	480 29	2, 805 29	845 67	18 21	863 88	10, 465 78	14, 134 [illegible]
November	2, 350 00	118 55	2, 468 55	835 00	179 70	1, 014 70	1, 873 25	5, 356 [illegible]
December	2, 566 24	237 80	2, 804 04	835 00	165 50	1, 000 50	5, 323 39	9, 127 [illegible]
1880.								
January	2, 301 35	130 10	2, 431 45	835 00	376 86	1, 211 86	367 10	4, 010 41
February	2, 371 68	152 51	2, 524 19	845 66	282 29	1, 127 95	370 73	4, 02[illegible]
March	2, 300 80	127 73	2, 428 53	835 00	220 31	1, 055 31	917 44	4, 401 [illegible]
April	2, 343 34	112 31	2, 455 65	858 00	309 38	1, 167 38	493 76	4, 116 79
May	2, 305 42	163 50	2, 468 92	891 34	67 08	958 42	248 48	3, 675 [illegible]
June	2, 499 15	100 18	2, 599 33	845 87	324 70	1, 170 57	424 57	4, 194 47
Total	28, 337 98	2, 332 15	30, 670 13	10, 196 19	3, 426 29	13, 622 48	32, 813 92	77, 106 [illegible]

Detailed statement of vessels passed through Louisville and Portland Canal during the fiscal year ending June 30, 1880.

Date.	Passenger boats.		Tow-boats.		Model barges.		Square barges.		Small boats.
	No.	Under tonnage.	No.	Under tonnage.	No.	Under tonnage.	No.	Measured capacity.	
1879.									
July	125	34, 639	8	949	27	6, 069	51	7, 756	38
August	85	24, 916	24	4, 590	45	12, 417	234	58, 205	29
September	85	30, 218	12	2, 113	30	7, 525	79	18, 512	42
October	40	8, 979	1	70	2	343	15	1, 626	56
November	62	19, 184	15	3, 294	20	5, 176	194	48, 159	72
December	91	37, 040	20	3, 914	26	7, 490	251	80, 591	47
1880.									
January	49	23, 287	17	2, 396	34	9, 856	201	58, 683	12
February	51	25, 260	21	3, 725	56	14, 084	138	40, 230	8
March	27	11, 678	12	2, 151	18	4, 845	152	47, 008	22
April	67	32, 611	24	3, 333	40	11, 413	185	51, 258	32
May	88	40, 672	34	4, 873	55	13, 719	88	21, 033	31
June	92	40, 267	47	7, 414	58	15, 491	206	58, 318	27
Total	862	328, 751	235	38, 822	411	107, 928	1, 794	491, 379	416

WORK OF DREDGING DEPARTMENT AND EXPENDITURES ON IT FOR THE FISCAL YEAR ENDING JUNE 30, 1880.

Dredging	days..	144½
Time lost:		
By high-water	do....	57
By employment on the improvement of the falls and old locks	do....	85
By Sundays and national holidays	do....	58
By assisting lock-hands other labor	do....	21½
Work:		
Cubic yards excavated during the year		60, 934
Cubic yards excavated per working day		421, 688
Salaries:		
For the year		$10, 196 19
Per day		33, 104 00
Repairs:		
For the year		2, 764 40
Per day		8, 975 00
Total:		
For dredging only		6, 080 53
Per working-day of actual dredging		42 08
Per cubic yard excavated		.099

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL FOR THE YEAR ENDING DECEMBER 31, 1879.

WAR DEPARTMENT,
Washington City, January 16, 1880.

The Secretary of War has the honor to transmit to the United States Senate, for the information of the Committee on Commerce, a copy of report of Maj. Godfrey Weitzel, of the Corps of Engineers, on the superintendence, management, and repair of the Louisville and Portland Canal for the year ending December 31, 1879, with letter of the Chief of Engineers submitting the same.

The report is approved; and in accordance with the provisions of section 3 of the act of Congress of May 11, 1874 (18 Stat., p. 44), the rates of toll existing during the year 1879, as stated in the letter of the Chief of Engineers, are declared and fixed as the charges to be collected for the current calendar year.

Respectfully submitted.

ALEX. RAMSEY,
Secretary of War.

The PRESIDENT
of the United States Senate.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 12, 1880.

SIR: To comply with the requirements of section 3 of the act of May 11, 1874, providing for the payment or the bonds of the Louisville and Portland Canal Company (Statutes at Large, vol. 18, part 3, page 43), I have the honor to submit herewith copies of the report of Maj. Godfrey Weitzel, Corps of Engineers, on the superintendence, management, and repair of that canal for the calendar year ending December 31, 1879, and of the receipts and expenditures for the same period.

It will be seen that the receipts during the past year amounted to the sum of $47,370.80, and the total expenditures during the same period to $81,604.23, an excess of expenditures over receipts of $34,233.43. The balance on hand January 1, 1879, was $57,793,14, and the amount on hand January 1, 1880, is consequently $23,559.71.

As in previous years, improvements and repairs, in the order of their necessity, were made as rapidly as a due regard for economy and expediency would permit, and it will be seen that the policy adopted of continuing to place the canal and its appurtenances in better working condition has gradually and steadily given increased facilities to its business.

During the last half of the year 1874, 274,365 tons were passed through the canal, at an expense of 9.12 cents per ton for superintendence, management, and ordinary repairs; in 1875, 757,695¾ tons, at 6.14 cents; in 1876, 871,446½ tons, at 5.6 cents; in 1877, 999,610 tons, at 4.97 cents; in 1878 (with rates of toll reduced 20 per cent.), 1,094.942 tons, at 4.65 cents; and in 1879 (on a business of about six months), 778,889 tons, at 5.63 cents per ton.

The total receipts on the canal from June 11, 1874, to December 31, 1879, the period during which the government has had charge, were $385,952.09; total expenditures, $362,392.38; leaving a surplus of $23,559.71. Of the expenditures, $112,719.92 were for permanent improvements.

The past year was the most unfavorable for the canal since 1875, it having been closed by ice, high-water, &c., 83 days. On this account, and in view of the large amount of work done in improvement and repairs, Major Weitzel recommends that the existing rates of toll, &c., be continued during the current year, viz:

Steamboats and model barges, 6¼ cents per ton.
Square barges, flats, coal-boats, &c., 5 cents per ton.
All empty square barges and coal-boats, 4 cents per ton.
Small boats, $4 each.

Rafts of logs, &c., measurements and rates the same as for coal-boats.
Boats belonging to or chartered by the United States, free.
Towing, harbor rates.
Use of dredge, $2.50 per hour.
Use of steam-pump, $2.50 per hour.
Use of dry-dock, $15 for the first day and $10 for each subsequent day.

A further reduction is not thought advisable in view of the fact that a number of repairs and improvements are yet to be made, and also for the reason that it is the part of prudence to keep a sufficient surplus on hand to provide for accidents more or less liable to occur on all canal-locks, and especially upon those of large dimensions.

Section 3 of the act of Congress referred to contains the following provision:

And to ascertain what rates will pay current expenses after the present year [1874], the Secretary of War shall, on the first Monday of January of each year, ascertain from the expenses of the previous year what tolls will probably pay the expenses of the current year; and he shall fix and declare the rate of tolls thus ascertained to be charged for the current year; * * * and he shall, in his next annual report, set forth such receipts and expenditures and the condition of said canal, with a view to such legislation as may be necessary for the superintendence and management thereof.

It is, therefore, respectfully recommended that the rates of toll above mentioned be adopted as those to be declared and fixed by your authority, in obedience to this law, as the charges to be collected for the current calendar year.

As the report of Major Weitzel contains matter of value relating to commerce and navigation, it is suggested that it be sent to Congress for the information of the Committees on Commerce of the Senate and House of Representatives.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen., U. S. A.

Hon. ALEXANDER RAMSEY,
Secretary of War.

REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., January 3, 1880.

GENERAL: In accordance with your instructions, and to enable the honorable the Secretary of War to comply with the provisions of section 3 of the act of Congress approved May 11, 1874, entitled—

An act providing for the payment of the bonds of the Louisville and Portland Canal Company—

I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the calendar year ending December 31, 1879:

Capt. A. N. Lee, Corps of Engineers, was my assistant in immediate charge of the work until his death, October 31, 1879. Since that time Mr. Phil. J. Schopp, who has been in the employ of the government, under my direction, on this work ever since the original surveys were begun, has been in immediate charge.

The usual tables are annexed for the practical information of the profession.

The policy which was adopted when the government assumed charge of this work has been continued. Improvements and repairs, in the

order of their necessity, were made as rapidly as economy and other circumstances would permit.

The following permanent improvements and repairs were made during the year, viz:

The grading, part paving, and part sodding of the extensive slopes on both sides of the new locks were finished, with the exception of the sodding of about one-half of the north slope. The berme between the foot of the slopes and the lock-walls on the south side was covered with a substantial concrete pavement of Portland cement, according to Ingalls's patent. This improvement has not only beautified the surroundings, but prevents the wash of mud from the slopes and bermes into the chambers, which heretofore occurred and caused much trouble and delay in the movement of the gates.

In addition to the usual repairs upon gates and machinery, a new set of chains and new winding machinery were introduced on the upper lift-gates, and new wooden suspension-masts erected at the lower lift gates.

The middle lift-gates are in poor condition, and the work of replacing them by new ones is now in progress. A great delay in this has been caused by the protracted low-water season of last fall and the difficulty of obtaining oak timber of proper dimensions.

The lower lift-gates are also showing signs of decay, and it will soon be necessary to replace them by new ones.

In due time it is also proposed to replace the wooden masts, from which the gates are virtually suspended, by iron columns. The former decay rapidly, and then it becomes very difficult to adjust the gate suspension-rods.

In the early part of the year I asked for and obtained authority to make the experiment of operating the gates by attaching a small engine to the gate machinery. It was made on the north leaf of the middle lift gates, as these are the heaviest and most difficult to operate. The experiment is a perfect success, and I have obtained authority and have purchased five additional engines for the other five leaves of the lift gates. When these are all in place and in operation, quite a reduction in the force of the lock hands can and will be made.

The work of rebuilding the old locks is completed, with the exception of hanging the gates. This will be done in a few days. The three chambers, each about 198 feet long, 50 feet wide, and having a lift of 8 feet 6¾ inches, have been converted into two chambers, having a capacity for passing vessels 258 feet long, 49½ feet wide, and having a lift of 12 feet 10 inches each.

These old locks are also furnished with a new set of guard-gates, and the upper lift-gates will soon require renewal.

This improvement of the old locks will assist materially in passing coal-vessels in the cases of coal-runs, which occur about three or four times a year, and cause delay for a short period, and will pass vessels during the short period, which has occurred a few times on a rising river, when the water has reached the 11½-foot mark on the canal-gauge. At this stage the new locks are impassable, and the falls also. The improved old locks permit passages to the 14½-foot stage by the canal gauge, and then the falls become passable for ascending boats.

The dry-dock is kept in serviceable condition by frequent minor repairs, but until the question of its enlargement to the capacity of the new lock-chambers is definitely determined upon, it is not economy to make extensive repairs.

There has not been so much work for the dredges during the year as in former years, owing to a less deposit being brought down by the

river; but both of them, as well as the tow-boat, have been profitably employed during their leisure from legitimate duties in various ways on the work of repair and improvement.

The tow-boat received a new coat of paint and new cylinder timbers, besides smaller repairs; the mud-scows were recalked; dredge No. 1 received a new crane, and dredge No. 2 minor repairs. The latter will soon require a new hull and boiler.

At the workshops no new machinery was added, but an additional shed was built from old material to protect the carpenters while at work on new lock-gates.

In addition to minor repairs on tow-boat, dredges, mud-scows, barge, and bridges, the shed above referred to was built and the following work was done, viz: A new dredge-crane and new guard-gates for old locks were constructed; the steam-engine at middle gates was placed in position; fences were completed; a new miter-sill for the lower gates of old locks laid; new anchor-bolts and suspension-rods for the new gates of old locks were made, and the timbers for the new middle gates of the new locks were planed.

A store-boat for the wickets and connecting-rods of the movable dam in the Indiana Chute, at the crest of the falls, and the bed timbers and plank for wickets were planed and prepared for the reception of trestles, and the whole structure set up and fitted at the shops, preparatory to being blaced in its position when the stage of water will permit.

The grounds around the superintendent's and collector's offices were filled in and improved with the material derived from grading the slope on the south side of the new locks.

The number of permanent employés is at present fifty, a reduction of one from last year. As soon as all the engines for operating the gates are in position there will be a considerable reduction in the permanent force.

The monthly pay-roll of the permanent force now amounts to $3,185.

The past year was the most unfavorable one for the canal since 1875. On this account, and the great amount of work done on improvements and repairs, the cash balance has been reduced during the year from $57,793.14 to $23,559.71. On this account I recommend that the present rate of tolls, &c., be continued during the present year.

During the year the canal was closed by ice and high-water 68 days, and for repairs 15 days; total, 83 days.

In July the water in the river went down, and, with the exception of a slight swell in August, it nearly touched extreme low-water mark, remaining down until November 23. This long-continued low stage had its bright side, however. It enabled us to do a great deal of work on the improvement, as well as on the superintendence, managment, and repair, at very economical prices. Practically, the business of the canal was, therefore, completely or partially suspended during about seven months of the year.

There were passed through the canal during the year 848 passenger-boats, 201 tow-boats, 356 model barges, 1,329 square barges, and 434 small boats; a total of 3,168 vessels, representing a registered under-tonnage and measured capacity of 778,889 tons.

Eleven million five hundred and eight thousand bushels of coal, 116,260 barrels of salt, and 20,155 tons of iron ore passed through during the year.

From June 11, 1874, to December 31, 1874, 274,365 tons were passed through, at an expense of 9.12 cents for superintendence, management, and ordinary repairs; in 1875, 757,695¾ tons, at 6.14 cents; in 1876, 871,446½ tons, at 5.6 cents; in 1877, 999,610 tons, at 4.97 cents; in 1878

(with rates of toll reduced 20 per cent.), 1,094,942 tons, at 4.05 cents; and in 1879 (on a business of about six months), 778,889 tons, at 5.63 cents per ton.

The receipts during the past year amounted to $47,370.80, and the total expenditures $81,604.23. The expenditures exceeded the receipts by $34,233.43. There was on hand at the beginning of the year the sum of $57,793.14; consequently, the amount on hand at the beginning of the present year is $23,559.71.

It will be seen by reference to the annexed table that, in spite of the unfavorable season, the receipts for the year exceed the expense of superintendence, management, and ordinary repairs by $3,486.49.

The amount expended for permanent improvements during the year was $37,719.92, and for running expenses, including ordinary repairs, was $43,884.31.

The total receipts on the canal from June 11, 1874, to December 31, 1879, during which period the government has had charge of it, amounted to $385,952.09, the total expenditures $362,392.38, leaving the surplus of $23,559.71.

Of the amount expended $112,719.92 was for permanent improvement. The total amount expended, therefore, for superintendence, management, and ordinary repairs, after deducting $23,559.71, the balance on hand at the beginning of this year, was $226,112.75.

During this period 4,786,949.05 tons (registered or measured capacity) were passed. The average expense per ton was, therefore, a fraction less than five cents per ton.

By the use of the canal force and machinery in the canal-shops a saving of about $30,000 below fair contract prices has been effected in the work already done.

Mr. Schopp, assistant engineer, superintendent of the canal, and his assistants have performed their duties in their usual praiseworthy manner. Mr. Schopp's report to me is embodied in the above.

Annexed hereto are the financial and other statements for the year.

Very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Financial statement for calendar year ending December 31, 1879.

Expenditures.		Deposits.	
Month.	Amount.	Month.	Amount.
1879.		1879.	
January	$3,240 00	January	[illegible]
February	4,282 91	February	[illegible]
March	1,233 66	March	[illegible]
April	8,350 44	April	[illegible]
May	5,936 12	May	[illegible]
June	5,876 21	June	[illegible]
July	7,282 89	July	[illegible]
August	496 91	August	[illegible]
September	7,388 24	September	[illegible]
October	8,897 47	October	[illegible]
November	18,646 39	November	[illegible]
December	9,972 99	December	[illegible]
Total	81,604 23	Total	47,370 80

Balance in bank December 31, 1878	$57,793 14
Excess of expenditures over receipts	34,233 43
Cash on hand December 31, 1879	23,559 71

Financial statement for calendar year ending December 31, 1879.

Receipts.	Amount.	Expenses.	Amount.
Tolls	$46,756 43	Lockage department	$30,928 47
Rents	252 50	Dredge department	12,955 84
Use of dry-dock	177 50	Improvements	37,719 92
Towage	107 50		
Use of pumps	16 87		
Use of dredge	60 00		
Total	47,370 80	Total	81,604 23

Balance in bank December 31, 1878	$57,793 14
Excess of expenditures over receipts in year 1879	34,223 43
Balance on hand December 31, 1879	23,569

Statement of the cost of superintendence, management, &c., for calendar year ending December 31, 1879.

Month.	Lockage department. Labor.	Lockage department. Purchases and repairs.	Lockage department. Lights.	Lockage department. Office expenses.	Lockage department. Total.	Dredge department. Labor.	Dredge department. Purchases and repairs.	Dredge department. Total.	Repairs and improvements.	Grand total.
January	$2,375 00	$168 39	$11 70	$75 10	$2,630 19	$795 00	$100 86	$895 86	$687 15	$4,213 20
February	2,375 00	45 19	5 67	16 50	2,442 36	841 66	260 00	1,101 66	127 75	3,671 77
March	2,375 00	101 75	......	27 50	2,504 25	835 00	225 95	1,060 95	1,565 91	5,131 11
April	2,340 00	199 97	7 00	......	2,546 97	835 00	263 11	1,098 11	934 68	4,579 76
May	2,325 00	327 15	6 61	58 88	2,717 64	835 00	150 77	985 77	2,451 35	6,154 76
June	2,325 00	123 38	6 04	......	2,454 42	835 00	709 39	1,544 39	3,033 42	7,032 23
July	2,325 00	193 81	5 99	24 00	2,548 80	835 00	395 35	1,230 35	2,187 16	5,916 31
August	2,325 00	119 50	5 78	......	2,450 28	899 65	350 24	1,189 89	6,431 60	10,071 77
September	2,325 00	230 68	......	......	2,555 68	835 00	134 78	969 78	2,688 48	6,153 78
October	2,325 00	428 01	11 98	40 30	2,805 29	845 67	18 21	863 88	10,465 78	14,134 95
November	2,350 00	46 49	10 06	62 00	2,468 55	835 00	179 70	1,014 70	1,873 25	5,356 50
December	2,566 24	175 54	15 56	46 70	2,804 04	835 00	165 50	1,000 50	5,823 39	9,117 93
Total	28,331 24	2,159 86	86 39	350 98	30,928 47	10,001 98	2,953 86	12,955 84	37,719 92	81,604 23

Work of dredging department and expenditures on it for the calendar year ending December 31, 1879.

Time dredging	132 days.
Time lost by ice	20 days.
by high-water	51 days.
by employment at falls and old locks	85 days.
by Sundays and holidays	58 days.
by assisting lock-hands and other labor	19 days.
Cubic yards excavated during year	51,338
Cubic yards excavated per working-day	388.92
Salaries for the year	$10,001.98
per working-day	$75.772
Cost repairs for the year	$2,953.86
per working-day	$22.377
for dredging, 132 working-days	$3,617.15
per working-day	$27.25
per cubic yard excavated	$0.704

Comparative general statement of receipts, expenses, &c., since the government assumed charge of the canal.

Year.	Receipts.						Total boats and tonnage.		Number of cubic yards dredged.	Number of days closed.	Number of lockages.	Cost per ton, including total cost of management.
	Source.											
	Tolls.	Dry-dock.	Towing.	Pump and dredges.	Rents.	Total.	Number.	Tonnage.				
												Cents.
1874*	$19,606 25	$464 28	$45 00	....	$280 00	$20,395 53	1,164	274,365.00	....	....	....	9.12
1875	68,664 75	599 21	350 00	....	501 65	70,175 61	2,881	757,695.75	90,488	93	1,401	6.14
1876	79,854 31	220 96	275 00	....	412 00	80,762 27	3,264	871,446.50	94,988	59	1,604	5.60
1877	87,907 78	195 00	146 00	$77 50	411 00	88,737 28	3,881	999,610.80	79,078	60	1,664	4.50
1878	77,737 60	234 00	108 50	101 25	329 25	78,510 60	4,086	1,094,942.00	67,526	33	1,820	4.05
1879	46,756 43	177 50	107 50	76 87	252 50	47,370 80	3,168	788,889.00	51,338	83	1,494	5.56
Total	380,527 12	1,890 95	1,032 00	255 62	2,246 40	385,952 09	18,444	4,786,949.05	383,418	328	7,983	....

Year.	Expenses.											
	Lockage department.					Dredge department.				Total superintendence, management, and repairs.	Permanent improvements.	Grand total.
	Labor.	Repairs.	Miscellaneous.	Office expenses.	Total.	Labor.	Repairs.	Miscellaneous.	Total.			
1874*	$15,199 78	$420 43	$405 09	$35 45	$15,960 75	$6,830 00	$459 96	$1,175 45	$9,065 41	$25,026 16	$115 95	$25,142 11
1875	28,265 57	700 63	513 18	39 08	29,518 41	12,873 19	884 22	3,309 56	17,066 97	46,585 38	3,174 11	49,759 49
1876	27,169 86	1,141 74	560 75	173 43	29,045 78	12,045 42	797 87	2,196 62	15,019 91	44,065 69	25,410 52	69,476 21
1877	28,608 77	2,020 65	1,088 02	139 38	31,856 82	10,869 31	378 86	2,245 61	13,493 78	45,350 60	15,591 82	60,942 42
1878	29,168 34	1,563 17	798 12	224 89	31,754 52	9,879 08	666 81	2,053 91	12,599 80	44,354 32	31,113 60	75,467 92
1879	28,391 24	1,457 46	788 79	350 98	30,928 47	10,001 98	1,104 98	1,848 88	12,955 84	43,884 31	37,719 92	81,604 23
Total	156,643 56	7,304 08	4,153 90	963 21	169,064 75	62,478 98	4,202 70	13,430 03	80,201 71	249,266 46	113,125 02	362,392 38

* From June 11 to end of year.

Statement of boats passed through the canal during calendar year ending December 31, 1879, with number and cost of lockages and amount and cost of dredging.

Month.	Number and undertonnage of steamboats, barges, small boats, &c., passed through the locks.										
	Passenger-boats.		Tow-boats.		Model barges.		Square barges.		Small boats.	Total.	
	No.	Under-ton'ge.	No.	Under-ton'ge.	No.	Under-ton'ge.	No.	Under-ton'ge.	No.	No.	Under-tonnage.
January	3	1,466	2	140	0	0	0	0	0	5	1,606
February	51	24,010	17	2,112	27	7,476	43	11,431	22	160	45,029
March	22	10,012	8	1,525	1	217	22	6,672	13	66	18,426
April	64	29,679	46	7,000	69	18,206	270	82,969	27	476	137,674
May	113	47,223	35	5,364	65	16,483	103	25,030	50	366	94,100
June	107	43,216	13	2,402	44	10,695	67	11,966	38	269	68,279
July	125	34,639	8	949	27	6,069	51	7,756	38	249	49,413
August	85	24,916	24	4,590	45	12,417	234	58,205	29	417	100,128
September	85	30,218	12	2,113	30	7,525	79	18,512	42	248	58,368
October	40	8,979	1	70	2	343	15	1,626	56	114	11,018
November	62	19,184	15	3,294	20	5,176	194	48,159	72	363	75,813
December	91	37,040	20	3,914	26	7,490	251	80,591	47	435	129,035
Total	848	310,582	201	33,473	356	91,917	1,329	352,917	434	3,168	788,889

Month.	Number of lockages.	Cost of lockages, including dredging.			Dredging cost per cubic yard.	Total cost.					
		Cost per lockage.	Cost per boat.	Cost per ton (undertonnage).		Cost per lockage.	Cost per boat.	Cost per ton (undertonnage).	Cost per bushel of coal.	Cost per ton of iron ore	Cost per barrel of salt.
									Cts.	*Cts.*	*Cts.*
January	5	$526 04	$526 04	$1 75	$0 399	$842 64	$842 64	$2 63	......	......	......
February	100	25 70	16 07	06	106	36 72	22 95	08	.099	......	......
March	40	101 75	61 67	22	243	128 28	77 74	28	.132	......	......
April	187	18 62	7 34	03	015	24 49	9 62	03	.200	5.16	.603
May	185	27 94	14 12	06	111	33 27	16 82	07	.144	3.90	.659
June	146	37 59	20 40	08	138	48 17	26 25	10	......	6.10	.856
July	145	32 32	18 82	09	522	40 80	23 76	12	.107	6.79	......
August	163	54 40	21 30	09	1 648	67 92	24 15	10	.107	7.00	.600
September	128	40 50	20 90	09	1 109	48 08	24 81	11	.143	......	......
October	65	204 17	116 41	1 20	....	217 46	123 99	1 29	......	......	......
November	136	31 92	11 96	06	....	40 12	14 75	07	.117	......	......
December	194	41 83	18 66	06	329	47 00	20 96	07	.110	......	......
Total	1,494	....	....	......	....	....	....	......	......	......	......

APPENDIX X.

IMPROVEMENT OF OHIO RIVER; OF MONONGAHELA RIVER, WEST VIRGINIA, AND OF ALLEGHENY RIVER, PENNSYLVANIA—HARBOR OF REFUGE NEAR CINCINNATI, AND ICE HARBOR AT THE MOUTH OF THE MUSKINGUM RIVER, OHIO.

REPORT OF MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS, BVT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 31, 1880.

GENERAL: I have the honor to submit herewith the annual reports on the works under my charge, for the fiscal year ending June 30, 1880.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

X 1.

IMPROVEMENT OF THE OHIO RIVER.

The following is a statement of the work done on the Ohio River during the fiscal year ending June 30, 1880:

WORKS OF CONSTRUCTION.

Davis Island (5 miles below Pittsburgh).—The movable dam under construction at this locality is in charge of Lieut. F. A. Mahan, Corps of Engineers. His annual report is as follows:

From June 30, 1879, work progressed vigorously until December 6, when everything had to close, owing to lack of funds. During this time all the land-wall, including the gate recesses, had been completed, except the coping; the filling and emptying culverts were built; the excavations were made for a length of 220 feet of the river-wall and for the Chanoine dam at the head of the lock; the concrete foundations were put in and completed for 205¼ feet of the river-wall and for the Chanoine dam; and about 85 per cent. of the stone floor of the Chanoine dam was laid.

The length of the development of the land-wall, including the gate recesses, is 1,169 feet. The foundation of the river-wall is 694 feet long, and the superstructure 689 feet.

The quantities of masonry put in are as follows:

Part of work.	Cubic yards cut stone.	Cubic yards rubble.	Cubic yards brick.	Cubic yards concrete.
Upper wall, lower recess		51.6		
Lower wall, lower recess	218.3	597.1		
Main landwall	857.9	1,532.8		
Chanoine Dam	109.6	36.2		
Filling conduit		160.2	120.8	
Emptying conduit		279.4	78.2	
Floor, upper recess		98.5		
Floor, lower recess		112.9		
Foundation river-wall				1,[illegible]
Foundation dam at head of lock				1,[illegible]
Sewer		27.7	10.1	
	1,185.8	2,896.4	209.1	2,6[illegible]

Making a total of 6,938 cubic yards of masonry of all sorts.

The accounts of the work have been kept with great care for details, and I had hoped to be able to present figures for use in making estimates. During the busy working season the accounts could not be kept up to date, and when the work ceased the office force was reduced to such an extent that the figures needed could not be made up. This work will therefore have to be postponed for the time being.

Portland Bar (603 miles below Pittsburgh).—Proposals for constructing a dike at Portland Bar were invited by advertisement dated September 1, 1879, the approximate of materials required being as follows:

700,000 feet, board measure, timber.
60,000 pounds iron drift-bolts.
18,000 cubic yards riprap stone.
150 cords brush.

The following bids were received and opened at Cincinnati on October 9, 1879:

Number.	Bidders.	Square timber per M.	Stone per cubic yard.	Brush per cord.	Iron per pound.	Aggregate.
1	E. G. Penn	$19 00	$0 84	$1 00	$0 04	$3[illegible]
2	Shipman Murphy	20 00	78	5 00	06	32,[illegible]
3	Hine & Magarity	19 75	88	2 00	05	32,[illegible]
4	Wheeler & Co	20 00	90	3 00	06	34,[illegible]
5	Jonathan Taylor	21 00	93	1 85	05½	35,[illegible]
6	James Burke	23 00	90	3 00	06	36,[illegible]
7	Jacob S. Lowry	22 50	97	1 50	05	36,[illegible]
8	Thomas P. Shanks & Co	27 50	90	1 50	05	[illegible]
9	Charles E. Clark	24 00	1 08	90	05	3[illegible]
10	Hill & McKechney	23 00	1 25	2 25	85	41,[illegible]
11	Willard Johnson	27 00	1 25	3 00	05	44,[illegible]
12	Colville & Howard	24 50	1 40	2 50	05	45,[illegible]
13	F. Jarecki	26 79	1 36	1 76	03¾	45,[illegible]
14	William H. Hawkins	28 50	1 50	2 00	06	5[illegible]
15	C. H. Callahan	38 50	1 35	3 50	07½	5[illegible]
16	McKenzie & Murphy	37 00	1 67	4 50	[illegible]	5[illegible]
17	Robert C. Kerr	35 00	2 50	3 50	07	74,[illegible]

A contract was made October 25, 1879, with the lowest bidder, Mr. E. G. Penn, of Amelia, Ohio.

The contractor has made considerable progress in collecting material, and will begin the actual work of construction as soon as the stage of water will permit. Nothing further has, thus far, been practicable since the contract was made.

French Island (760 *miles below Pittsburgh*).—The repairs of this dike, authorized by letters of the Chief of Engineers dated November 7, 1878, and August 9, 1879, were completed in November, 1879. The dike has been strengthened for a distance of 1,890 feet from its root (about one-half its entire length), by a row of piling driven along its upper or channel face and connected by horizontal wale pieces bolted near their tops; the whole being supported by a backing of brush and stone placed on the sloping face of the dike. It is expected that this revetment will enable the dike to withstand the effect of ice, which has hitherto been the cause of annual damage.

The dike now turns the water at the 6-foot stage. The amount of material expended during the season, June 12 to November 30, 1879, is as follows:

1,006 piles,
456 cords brush, and
6,749 cubic yards of stone.

The work of repair was done by contract with C. M. Cole, the contractor for Evansville Dike, and at the prices named in the contract for the latter work.

Evansville, Indiana (783 *miles below Pittsburgh*).—The repairs of this dike, under contract with C. M. Cole, dated September 30, 1878, were completed during the month of September, 1879. A spur-dike to arrest the scouring action developed below the main dike has also been constructed. This dike starts from the Kentucky shore about 300 feet below the root of the main dike and extends some 240 feet into the river; it has a width of 25 feet and its top is at the height of the 8-foot stage. The amount of material expended on these dikes (June 1 to September 27) is as follows:

75 piles,
735 cords brush, and
6,692 cubic yards stone.

Henderson Island (796 *miles below Pittsburgh*).—The repairs of the dike and dam at Henderson Island, authorized by department letter of September 25, 1879, were made between October 15 and December 5, 1879.

Three hundred and fifty cubic yards of stone were expended in repairing a gap in the dike which projects from the Indiana shore, and 339 cords of brush and 1,722 cubic yards of stone were used in strengthening the dam which closes the chute on the Kentucky side of the island.

This work was also done by contract with the contractor for the Evansville Dike, and at the same prices.

Grand Chain (943 *to* 948 *miles below Pittsburgh*).—An allotment of $50,000 for the improvement of the Grand Chain was contained in the river and harbor act approved June 18, 1878, and a similar allotment of $50,000 was contained in the river and harbor act approved March 3, 1879. Of the first allotment, $5,700 was expended in removing the "Arkansas" and other rocks (as reported in my last annual report) and, with the $44,300 left, it was thought best to build a longitudinal dike, terminating in the vicinity of the "Jackson" Rock. The design of this dike was to fence off the shore ledges that were too expensive for removal, and to increse the bottom scour so as to develop the rocks that now lie half buried and are almost undiscoverable.

Bids for this dike were opened on the 27th of June, 1879, with the following result:

Number.	Bidders.	Round timber per linear foot.	Square timber per M.	Stone per cubic yard.	Brush per cord.	Iron per pound.	Aggregate cost of dike constructed wholly of round timber.	Aggregate cost of dike with superstructure of sawed timber.
1	C. M. Cole	$0 07	$18 00	$0 88	$1 50	$0 03½	$33,060 00	$39,482 [illegible]
2	Thomas P. Shanks & Co	10	17 50	99	75	3½	39,780 00	44,9[illegible]
3	James Burke	10	17 00	1 00	75	04	40,375 00	45,6[illegible]
4	J. S. Routh	10	25 00	1 15	1 00	03	43,300 00	51,3[illegible]
5	J. S. Lowry	14	22 00	90	1 25	03½	44,576 00	50,4[illegible]
6	Kirby & Shipman	14½	18 75	82	2 50	04½	44,615 00	49,304 [illegible]
7	E. G. Penn	10	18 00	1 25	3 00	03	46,500 00	51,7[illegible]
8	M. D. Burke	14	21 00	1 00	1 50	04	47,150 00	52,7[illegible]
9	Black & Coyne	14	22 50	1 05	1 10	03½	47,800 00	54,225 [illegible]
10	Peter & Scully	10½	20 45	1 37½	1 87	05	50,885 00	57,741 [illegible]
11	B. L. Wood, jr	16	29 00	1 23	95	03	54,635 00	62,415 [illegible]
12	James McArthur	18	24 00	1 25	1 00	04	58,800 00	64,3[illegible]
13	Coplinger, Kirk & Howard	18½	19 50	1 60	4 75	04	69,175 00	72,8[illegible]
14	J. S. McDonald	20	24 00	1 66	1 66	04½	71,600 00	76,7[illegible]
15	McKenzie & Murphy	31	34 00	1 65	4 50	02¾	89,525 00	94,6[illegible]
16	Ph. Gebertshan	80	80 00	2 60	5 00	04½	189,825 00	198,3[illegible]

A contract for this dike was made July 12, 1879, with the lowest bidder, C. M. Cole, of Marietta, Ohio.

Subsequently the embargo on the appropriations of March 3, 18[illegible] was removed and bids were invited for the construction of another dike, whose terminus was to be the "Suwannee" Rock near the foot of the chain. The bids were opened on October 9, 1879, with the following results:

Number.	Bidders.	Round timber per linear foot.	Square timber per M.	Stone per cubic yard.	Iron per pound.	Brush per cord.	Aggregate of [illegible]
1	C. M. Cole	$0 07	$20 00	$0 98	$0 07	$1 50	$46,5[illegible]
2	Jonathan Taylor	09½	17 75	98	05½	1 50	4[illegible]
3	Thomas P. Shanks & Co	09½	18 00	95	05½	1 25	49,[illegible]
4	Shipman & Murphy	11	21 00	81	06	2 00	50,[illegible]
5	James Burke	09½	18 00	97	07	1 25	51,[illegible]
6	Jacob S. Lowry	10½	22 50	98	05	1 50	53,[illegible]
7	Colville & Howard	10	19 00	1 30	05	1 00	58,[illegible]
8	Hill & McKeehney	15	22 00	1 50	05	2 25	73,[illegible]
9	Upton & Johnson	20	24 00	1 30	05	4 00	81,[illegible]
10	Willard Johnson	25	28 00	1 12	05	3 30	81,[illegible]
11	McKenzie & Murphy	57	35 00	1 85	04½	5 00	10[illegible]

The contract was awarded to the lowest bidder, C. M. Cole, of Marietta, Ohio, and was executed October 25, 1879.

The first dike starts from the Illinois shore, above the Jackson Rock, and curves down stream, gradually becoming parallel with the current. It is to have a length of 3,000 feet, and will be built to a height of 8 feet above low-water, with a width of 20 feet. Up to the height of 4 feet above low-water the dike will consist of separate cribs of round timber, 30 to 50 feet long, placed end to end as nearly in contact as possible, and filled with stone. On the top of the independent bottom cribs, or from 4 to 8 feet above low-water, will be placed a superstructure of square timber. This superstructure will have a width of 18 feet, and will be a continuous work, connecting and firmly binding together the independent bottom cribs. Work was begun on this dike on November 10, and was continued until the end of December. During this time the

substructure was extended for a distance of 250 feet from the bank, and the shore protection at the root of the dike was nearly completed; a portion of the superstructure was also built.

The dike at the foot of the chain starts from the Illinois shore, and runs down stream in a curve, gradually becoming parallel with the current, and terminating at the "Suwannee" Rock. It is also to have a length of 3,000 feet, and is to be built in all respects in a similar manner to the one at the head of the chain. Work was begun in May, 1880, but owing to high-water it has thus far been necessarily limited to the bank protection at the root of the dike and to the collection of material for construction.

Removal of rocks.

During October and November the Ohio was unusually low, and both the snag-boat and dredges were compelled to tie up. I therefore directed that their crews be employed in removing rocks from the bed of the river by blasting or otherwise. With the approval of the Chief of Engineers, several other parties were also organized for this work. The opportunity was a very unusual one, and although the work was soon stopped by a rise, the benefits were very great, and were highly appreciated by the river interests. The following is a detailed statement of the work done by the several parties:

The party under charge of Capt. John Gordon, of Pittsburgh, began work at *White's Ripple and the Trap*, 11 miles below Pittsburgh, on October 7. After thoroughly removing the troublesome rocks from this shoal, the party worked upstream to *Deadman's Island, Merriman's Ripple, Duff's Bar, and Lowrie's Ripple.* Good work was done at each of these places. The rocks were generally removed by means of stone-sleds drawn by horses, the larger rocks being broken up with powder to a size that would admit of their being handled. Work was closed on November 15.

The party under charge of Capt. Marsh Hays removed a cluster of rocks from *Beaver Shoals*, 27 miles from Pittsburgh, between October 2 and October 9.

Crew of dredges.—The work done by this party has been tabulated by the engineer in charge, as follows:

Place.	Rocks removed.	Weight in tons.
Lowrie's Ripple	108	35.9
Duff's Bar	9	6.5
Merriman's Bar	45	23.5
Hays' Bar	2	5.0
White's Ripple	2	4.5
Sewickley	8	13.0
Deadman's Island	398	73.2
Big Sewickley Creek	103	12.0
Economy, Pa	2	3.5
Baden, Pa	108	19.8
Knox's Bar	635	77.1
Baker's Yard	36	3.0
Lacock's Bar	1,369	144.5
Perry's Reef	195	41.1
Rochester	1	7.9
Beaver Bar	390	58.0
Do	Ledge ..	60.0
Beaver Shoals	342	95.2
Raccoon Bar	206	38.7
Montgomery Island	272	94.3
Do	Ledge ..	32.0
Phillis' Island	1,987	153.0
Georgetown Island	714	97.7
Line Island	580	127.9
Do	Ledge ..	125.2
Total	7,512	1,352.5

Party under direction of Capt. J. B. Daniels, of Harmar, Ohio, worked from October 20 to November 1 in removing rocks from channel at *Bogg's Island*, *McMahon's Creek Bar*, and *Little Grave Creek Bar*, situated, respectively, 2½ miles, 4 miles, and 10 miles below Wheeling, W. Va. At the two first-named places the channel was thoroughly cleaned of rocks. The work at Little Grave Creek was not finished on account of cold weather. Four thousand four hundred and seventy rocks of various sizes were removed by this party.

Party under charge of Capt. J. R. King, of Belpre, Ohio, worked on the following shoals, situated between 11 and 49 miles below Parkersburg, W. Va., viz, *Mustapha Island*, *Lee Creek Bar*, *Swan Bar*, *Sand Creek Bar*, *Great Bend Shallows*, and *Letart Falls*, from October 21 to November 15. About 1,300 rocks were taken from these shoals, some of which would contain several cubic yards each; about one-third of the whole number would average 1 cubic yard in volume, the rest measuring from 1 to 5 cubic feet each. The low-water channel was much improved at each of the places named.

Crew of snag-boat.—On account of the extreme low-water which prevailed during the latter part of the season, the snag-boat was unable to work, except for one or two days, from September 17 to November 18, a little over two months. While the boat was thus laid up, the crew were employed in removing the troublesome rocks from *Greenup Shoals*, *Pogue's Shoals*, and *Sandy Shallows*, greatly improving the channel at these points. Two very large rocks were also removed from the channel opposite *West Ironton, Ohio;* these rocks averaged about 45 cubic yards each, and were very difficult of removal.

A total of 2,055 cubic yards of stone was removed by the snag-boat crew while the boat was laid up.

The party under direction of Mr. Philip Golay, assistant engineer, began operations on the river below Evansville on October 19, and worked until November 25.

At *Highland Rocks*, near Uniontown, Ky., 51 miles below Evansville, about 1 foot in depth was removed from the surface of the "*Cave Rock* (a portion of the ledge about 100 feet long and 10 feet wide). The remnant of this rock is now covered by a little more water than is found on the bars immediately above and below it. This rock was found to be composed of indurated clay or soapstone. At *Weston, Ky.*, 81 miles below Evansville, 21 rocks, containing from 3 to 12 cubic yards each, were removed from the channel. At *Prior's Island*, 110 miles below Evansville, 29 rocks were removed from the channel by blasting and lifting out the large fragments with a crane-boat; 16 rocks were also removed from a rock-bar opposite the island. At the *Sisters Islands*, 113 miles below Evansville, 75 cubic yards of small stones were removed from the channel. At the *Grand Chain* the channel was improved by removing a depth of 14 inches from the top of the "*Jackson*" *Rock*. Ten isolated rocks, averaging 2 tons each, were removed from the vicinity of the "*Grenadier*" *Rock*. Two large rocks near the channel below the "*Arkansas*" *Rock* were blasted and scattered into deep water, and 4 large rocks near the foot of the Chain were also blown to pieces and removed from the channel.

SNAG-BOAT E. A. WOODRUFF.

The snag-boat E. A. Woodruff began work for the season on June 1, and worked over the river as follows: Cincinnati to Wheeling; Wheeling to Cairo; Cairo to New Cumberland, W. Va.; New Cumberland to Evansville; Evansville to winter quarters in the mouth of Green River.

One thousand and seventy-four snags and 48 wrecks were removed during the season. Among the wrecks removed were those of the Rebecca, at Parkersburg; the Brilliant, at Gallipolis; the J. C. Crosley, just below the mouth of the Guyandotte; the Nat. Holmes and the David Gibson, at Petersburg; the Arlington, at Smithland, and the remnant of the Pat. Cleburne, at Cincinnati tow-head; a model barge at Sehon's Landing, and one at Cairo, Ill.; a stone-boat at Howard Jenkins' Landing, and one at Nine-Mile Bar, and a salt-boat at New Albany, Ind.; the remainder being wrecks of coal-barges.

The two largest snags taken out were a cottonwood at Grissom's Landing, Ky., and an elm at the mouth of the Big Guyandotte River; the former was 100 feet long, 6 feet 6 inches in diameter at the butt, with a root spreading to a diameter of 30 feet. The weight of this snag, including the stump, was 210 tons, being the heaviest yet removed by the boat. The other one was 79 feet long, 9 feet 10 inches in diameter, with root spreading 26 feet, and weighed 193 tons. Both of these snags were full of limbs. On the 30th of June, the snag-boat removed the snag which sunk the Salt Valley, at Point Run Landing; on December 1, the snag which sunk the Fashion, three or four years ago; and on December 2, the snag which sunk the Granite State, at Warren's Landing.

UNITED STATES DREDGES OHIO AND OSWEGO.

Davis' Island (5 miles below Pittsburgh).—The work of excavating for foundations of the lock at Davis' Island, begun before the close of the last fiscal year, was continued by one of the dredges (the Ohio) until June 18, when the river became too low to admit of further work. Excavation made in July, 3,733 cubic yards. Total excavation, June and July, 1879, 15,322 cubic yards.

Foot of the Trap (12 miles below Pittsburgh).—The work of removing a lump from the channel at the foot of the trap, begun June 26, was completed on July 1. Excavation, July 1, 890 cubic yards. Total excavation, 1,949 cubic yards.

Foot of Merriman's Bar (10½ miles below Pittsburgh).—One cut was taken from the gravel point which projected from the right bank of the river, widening the channel some 40 feet and straightening it materially. Excavation made July 2, 3, 25, and 26, 2,394 cubic yards.

Middletown, Pa. (11 miles below Pittsburgh).—The opening in the dike at White's Ripple, opposite Middletown, was enlarged to a width of 250 feet, so as to make a safe passage through to the Middletown steamboat landing. The usefulness of the dike is in nowise impaired by this opening, as the cross-dam just below effectually prevents any waste of water through it from the main channel of the river. Amount of excavation, July 5 to July 23, 4,184 cubic yards gravel and 2,760 cubic yards loose rock.

Line Island (41 miles below Pittsburgh).—The channel at the head of Line Island has been widened 120 feet by dredging off the points of the bars projecting from the Virginia shore and from the island. Total excavation, July 31 to August 25, 22,172.4 cubic yards. This channel was materially widened by the dredges in 1874, but ascending tows still found trouble on scant water.

Stoop's Ferry (13 miles below Pittsburgh).—A little more than one day's work was done by the Ohio in dredging out the government quarry-landing at Stoop's Ferry, which had become partly filled up by wash

from the creek since June. Excavation, August 28 and 29, 416.7 cubic yards.

Foot of Deadman's Island (14½ *miles below Pittsburgh*).—A sudden rise in Little Sewickley Creek having thrown out a bar at the mouth of the creek, which would render the passage of tows impossible, except at the highest stages, the dredge Oswego commenced its removal on August 27, and worked until September 9, at which time the river had fallen so low as to make it impossible to continue dredging. The work at this place was, however, practically completed before the suspension of work. Total excavation, 6,146.4 cubic yards.

A similar bar was formed at this place in 1875, and was removed by dredging in 1876, at which time also a dam of brush and stone was built across the mouth of the creek to change its course and thus prevent the formation of a troublesome bar. This dam, although successful in changing the course of the stream, did not prevent the reformation of the bar a little further down, and it was therefore deemed advisable to construct another dam to still further change the course of the stream. This second dam was commenced on August 29, by the crew of the dredge Ohio, and was completed on September 6. It is [illegible] feet long and contains 30 cords of brush, 228 cubic yards of stone, and 34 cubic yards of gravel. It is hoped that its construction will prevent any further trouble from bars at this place.

Pike's Island (83 *miles below Pittsburgh*).—After completing the removal of the bar at Deadman's Island, on September 9, the dredges were unable to resume work until November 22, when they began the removal of the Creek Bar on the Ohio shore, opposite the foot of Pike's Island, so as to straighten the channel. This work was completed on December 12, and the dredges were taken at once to winter quarters at the mouth of the Muskingum River. Total excavation at Pike's Island, 23,483.3 cubic yards.

Iron hull for dredge Ohio.—The wooden hull of the dredge Ohio being finally worn out, it was determined to build the new hull of iron, and the cost of such a hull was included in my annual report for 1879. Bids were invited for the construction of this hull, to be opened on the 1st of October, 1879. The only bid received was that of Theodore Allen, of Saint Louis, who proposed to build the hull for $21,950. With the approval of the Chief of Engineers, a contract was entered into with Mr. Allen on October 25, 1879.

The scarcity of bidders was due to the fact that the iron "boom" had set in, and it was almost impossible to get the mills, which were overwhelmed with orders, to make contracts for iron for future delivery.

The hull was completed and delivered at Cincinnati on May 10, 18[illegible]. The dredge crews were immediately set to work to transfer the old machinery to the new hull and to prepare it for service. Three weeks after the close of the fiscal year the *Ohio* began her season's work.

The following tables show the details of the work done by the dredges during the year 1879:

DREDGES IN COMMISSION, 1879.

	Days
Time at work:	
Dredging	[illegible]
Wrecking	[illegible]
On Little Kanawha River	[illegible]
Time lost:	
Traveling	6
Accidents	13
High-water	[illegible]

	Days.
Low-water	17
Sundays	23
Total	155
Total on Ohio River	152
Work:	
Cubic yards excavation, gravel, &c	75,692.8
Cubic yards excavation, rock	5,487.4
Total	81,180.2
Number wrecks removed	1
Cost:	
Equipment—	
For the season	$518 37
Per day of work	5 89
Per day in commission	3 41
Towing:	
For the season	5,095 35
Per day of work	57 77
Per day in commission	33 52
Salaries:	
For the season	4,965 98
Per day of work	56 43
Per day in commission	32 68
Repairs:	
For the season	288 47
Per day of work	3 16
Per day in commission	1 90

DREDGES OUT OF COMMISSION.

	Days.
Time:	
In ordinary	174
Annual spring repairs	36
Total	210
Cost:	
Salaries in ordinary	$1,405 00
Annual spring repairs	3,219 68
Total	4,624 68
Per day in ordinary	8 08
Expenditures:	
For dredging	$15,401 71
For wrecking	91 14
Total for 1879	15,492 85
Per day in commission	119 26
Per day of work	182 27
Per cubic yard gravel, &c	18
Per cubic yard rock	315

1879.	Miles from Pittsburgh.	Place.	Kind of work.	Days of work.	Excavation.				Expenditure.			
					Cubic yards gravel, clay, &c.	Cubic yards rock.	Cubic yards per day of work.	Cost per cubic yard.	Total for ordinary dredging.	Total for dredging rock.	Total for wrecking.	Grand total.
May, June, July		Davis Island	Gravel	22	15, 363. 9		698. 4	$0. 260	$4, 009 91			$4, 009 91
June		Stoop's Ferry	Rock	5		2, 310. 7	462. 1	0. 390		$911 35		911 35
Do		Sewickley	Barge wreck	½							$91 14	91 14
June, July		The Trap		2	1, 949. 1		974. 6	0. 187	364 54			364 54
July		Middletown Dike	Rock	3½		2, 760. 0	788. 6	0. 231		637 98		637 98
Do		do	Gravel	4	4, 184. 0		1, 046. 0	0. 174	729 08			729 08
Do		Foot Merriman's Bar	do	2		2, 393. 7	1, 196. 8	0. 152	364 54			364 54
July, August		Line Island	Gravel and clay	19	22, 172. 4		1, 167. 0	0. 156	3, 463 11			3, 463 11
August		Stoop's Ferry	Rock	1		416. 7	416. 7	0. 437		182. 27		182 27
August, September		Foot Deadman's Island	Gravel	9	6, 146. 4		682. 9	0. 276	1, 640 42			1, 640 42
November, December		Foot Pike Island	do	17	23, 483. 3		1, 381. 4	0. 132	3, 098 56			
Total				85	75, 692. 8	5, 487. 4			13, 670 16	1, 731 55	91 14	15, 492 85

SPECIAL SURVEYS.

During the extreme low-water season between October 15 and December 31 special surveys were made to determine the improvement required at the following bars, viz: Head of Three Brothers, Rowland's Race, Sand Creek, Oil Creek, Puppy Creek, Three-Mile Island, Blakely Bar, Caseyville, Tradewater, Walker's Bar, and Cottonwood Bar.

SEDIMENT OBSERVATIONS.

The sediment observations ordered by department letter of August 30, 1878, were completed on December 30, 1879, and the result of the observations, covering the entire year 1879, has been sent to Col. Z. B. Tower, Corps of Engineers, to be turned over to the Mississippi River Commission.

COMMERCE OF OHIO RIVER.

It is usual to obtain commercial statistics from the custom-house returns, but as the commerce of the Ohio is wholly inland, and therefore not subject to duties, no official records are kept from which to obtain its amount or value.

The Chamber of Commerce of Cincinnati for its own information keeps a record of the chief exports and imports by boats and barges that land at this city, but even these records do not include a large amount of coarse articles, such as sand, gravel, riprap, stone, &c., which come by flat-boats and open barges, and which are not reported on 'Change.

The following table, taken from the thirty-first annual report of the Cincinnati Chamber of Commerce (for the year ending August 31, 1879), gives the destination of the principal articles exported from Cincinnati by water during the year 1878–'9:

Articles.	To New Orleans.	To other down-river ports.	To up-river ports.	Total.
Alcohol ... barrels	18	416	127	561
Ale, beer, and porter ... do	1,259	2,387	15,377	19,023
Apples ... do	7,525	31,496	2,376	41,397
Bagging ... pieces	2,988	13,425	10	16,423
Barley ... bushels	500	11,296	4,124	15,920
Beans ... do	798	822	2,811	4,431
Beef in barrels ... pounds	185,400	27,200	49,820	262,420
Beef in tierces ... do	15,300	66,640	18,360	90,300
Boots and shoes ... cases	659	14,892	14,540	30,091
Bran, ship-stuff, &c ... tons		55	1,176	1,231
Brooms ... dozens	2,234	2,527	1,329	6,090
Broom-corn ... pounds	149,600	27,900	260,100	437,600
Butter ... barrels	218	90	9	317
Butter ... firkins and kegs	12,607	4,950	455	18,012
Candles ... boxes	23,957	10,721	7,755	42,433
Castings ... pieces	2,988	5,156	1,180	9,324
Castings ... tons	267	760	116	1,143
Cattle ... head	98	1,285	772	2,155
Cement and plaster ... barrels	134	1,752	12,111	14,007
Chairs ... dozens	2,719	2,324	5,274	10,317
Cheese ... boxes	4,393	8,613	9,369	22,375
Coffee ... bags	167	18,969	15,706	34,842
Cooperage ... pieces	15,519	31,476	9,484	56,479
Corn ... bushels	93	3,388	414,777	418,258
Corn-meal ... barrels	119	263	2,933	3,315
Cotton ... bales	696	88	4,827	5,611
Crockery, &c ... packages	882	3,610	79	4,571
Eggs ... boxes and barrels	100	6	451	557
Feathers ... bags	3		179	182
Fish ... barrels	210	4,638	612	5,460
Fish ... kegs and kits	877	8,798	8,035	17,710
Flour ... barrels	1,071	5,183	52,607	58,861

Articles.		To New Orleans.	To other down-river ports.	To up-river ports.	Total.
Fruit, dried	bushels	1,341	11,454	10,552	[illegible]
Furniture	packages	49,120	19,805	25,590	[illegible]
Glass	boxes	6,490	13,037	2,131	[illegible]
Glassware	packages	14,198	60,504	5,194	[illegible]
Grease	tierces	30	494	518	[illegible]
Hardware	boxes and casks	4,379	48,602	16,885	[illegible]
Hay	bales	1,366	372	1,688	[illegible]
Hemp	do	23	163	311	[illegible]
Hides	number	....	20,765	18,439	[illegible]
Hogs	do	31	3,537	14,299	[illegible]
Hog product, bacon	pounds	1,872,570	3,805,794	4,381,930	[illegible]
Hog product, hams	do	1,199,020	806,882	1,569,617	[illegible]
Hog product	barrels	6,131	1,586	5,594	[illegible]
Hog product, in boxes	pounds	344,500	505,000	4,684,000	[illegible]
Hog product, bulk	do	54,600	380,780	6,772,355	[illegible]
Hops	bales	50	138	14,299	[illegible]
Horses	head	222	1,620	3,342	[illegible]
Iron, pig	tons	66	1,896	1,432	[illegible]
Iron and steel	pieces	25,675	82,981	23,750	[illegible]
Iron and steel	bundles	16,293	23,916	3,387	[illegible]
Iron and steel	tons	1,107	12,290	1,303	[illegible]
Lard in tierces	pounds	284,130	613,820	1,416,670	[illegible]
Lard in kegs	do	26,865	72,700	24,990	[illegible]
Lead, white	kegs	524	21,102	19,805	[illegible]
Leather	bundles	190	1,000	2,333	[illegible]
Lime	barrels	6	1,020	8,809	[illegible]
Malt	bushels	2,000	36,768	25,404	[illegible]
Manufactures, sundry	packages	3,937	917	541	[illegible]
Merchandise, sundry	do	28,496	161,137	206,282	[illegible]
Merchandise, sundry	tons	1,184	1,456	210	[illegible]
Molasses	barrels	11	2,554	14,527	[illegible]
Nails	kegs	49,185	168,129	3,750	[illegible]
Naval stores	barrels	8	862	868	[illegible]
Oats	bushels	108	3,544	161,679	[illegible]
Oil	barrels	4,553	21,284	11,915	[illegible]
Oil-cake	tons	....	....	5	[illegible]
Onions	barrels and sacks	1,411	1,007	294	[illegible]
Peanuts	bags	11	521	4,177	[illegible]
Potatoes	barrels and sacks	2,085	5,213	13,984	[illegible]
Rope, twine, &c	packages	1,119	4,588	1,455	[illegible]
Rye	bushels	....	22,284	9,942	[illegible]
Salt	barrels	1,096	36,175	870	[illegible]
Salt	bags	50	901	30	[illegible]
Seed, flax	sacks	....	12	520	[illegible]
Seed, grass and clover	do	....	3,373	13,099	[illegible]
Sheep	head	1,098	430	241	[illegible]
Soap	boxes	36,352	46,979	39,801	[illegible]
Spices	packages	85	639	132	[illegible]
Starch	boxes	33,593	22,760	18,536	[illegible]
Stearine	tierces	5	20	247	[illegible]
Sugar	hogsheads	3	962	2,420	[illegible]
Sugar	barrels	96	11,141	12,832	[illegible]
Tallow	tierces	18	36	175	[illegible]
Tobacco, leaf	hogsheads	283	754	5,904	[illegible]
Tobacco, leaf	boxes and bales	111	814	972	[illegible]
Tobacco, manufactured	packages	1,174	12,270	11,001	[illegible]
Vinegar	barrels	2,279	5,474	1,424	[illegible]
Wheat	bushels	38	7,098	113,822	[illegible]
Whisky	barrels	17,422	43,454	22,062	[illegible]
Wine and liquors	do	249	1,770	1,339	[illegible]
Wine and liquors	baskets and boxes	2,393	3,917	1,067	[illegible]
Wool	bales	10	703	1,327	[illegible]

This table embraces solely such exports as are daily reported on the books of the Merchants' Exchange, but does not include any movement embraced in supplemental reports or returns. (See crockery, cooperage, horses, oil, pig-iron, salt, and starch.

The reports on these latter articles do not separate the shipments by river from those by rail or canal, and they cannot therefore be used to complete the table.

The following table, compiled from the report above named, shows the number, tonnage, and movements of steamboats, tow-boats, and model

barges which plied between Cincinnati and other ports during the year ending August 31, 1879:

	Number.	Total tonnage.	Arrivals of steamboats.	Departure of steamboats for—				
				New Orleans.	Pittsburgh.	Saint Louis.	Other ports.	Total.
Steamboats	98	38,866						
Tow-boats	130	22,916						
Model barges	84	21,787						
Total	312	83,569	2,725	97	162	75	2,396	2,730

STEAMBOATS AND MODEL BARGES BUILT AT CINCINNATI DURING THE YEAR.

Steamboats	12	Tonnage	6,832
Model barges	3	Tonnage	810
	15		7,642

Schedule of rates by river on fourth-class freight from Cincinnati, during year ending August 31, 1879.

	Pittsburgh.	Louisville.	Saint Louis.	Memphis.	New Orleans.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Highest	15	10	15	25	40
Lowest	15	10	10	20	20

The summary of the present status of the river commerce of Cincinnati is thus stated in the report:

To sum up the whole year's work, the general situation is encouraging. The character of the boats is steadily improving. The popularity of river travel is increasing, which is being the more stimulated by regular methods of departure and arrival. Important problems, it is true, remain to be solved, but in the main the river interest of Cincinnati enters on the new year with the reasonable promise of fair compensation to itself, and promise of increased usefulness to the people of the great district tributary to this city.

At Pittsburgh the only available statistics are those kept by the coal exchange, and these refer exclusively to their own business. They are as follows:

Coal shipped during 1879	bushels..	62,015,300
Coke shipped during 1879	bushels..	3 572,700
Total		65,588,000

This is a decrease from 1878 of 11,237,255 bushels, due to strikes at the mines.

There are no other statistics that can be obtained without great labor. In 1869 my predecessor, Mr. W. Milnor Roberts, caused to be compiled as accurate a statement of the value of Ohio River commerce as could be obtained, and he concluded that its annual value was $694,000,000. I think that this estimate is somewhat too large, but I have no reliable means of checking it.

WORK DURING 1880–'81.

The approved programme for the ensuing year is as follows:

Work will be continued on the Davis Island Dam; and it is hoped that the river wall of the lock will be finished before winter, so that the coffer-dams may be removed.

The snag-boat will patrol the river as usual.

The dredges will work between Brush Creek and Louisville.

Work will be continued on the dikes at Four-Mile Bar, the dike at Portland, and the dikes at the Grand Chain. The dikes at Four Mile will probably be completed, and possibly the others also; but the latter are more affected by rises in the river, and it is difficult to secure a sufficiently long season for effective work.

ESTIMATE FOR 1881–'82.

During the fiscal year 1881–'82 funds will be required for continuing work on the Davis Island Dam, for the current expenses of removing snags and of dredging for the removal of rocks, for the construction of dikes and dams, and for office and miscellaneous expenses and contingencies.

The appropriation of June 14, 1880, for the Davis Island Dam was too small, and too long delayed to secure satisfactory results during the present season. It is expected, however, that the lock will be completed to at least such a height as will permit the removal of the coffer-dams and thus save the difficulty and cost of protecting them from the winter's ice.

For continuing operations on this work we need at least $200,000, and I would earnestly request that, whatever reductions may be found necessary in the appropriations, this sum be left intact.

For the annual expenses of snagging, $25,000 is needed.

For the annual expenses of dredging, $16,500 is needed.

For the removal of loose rocks and bowlders, we ought to have at least $5,000. This work can only be done in very low water, and hence can extend over but a short period. Similar work heretofore done has given very great satisfaction.

There are so many dikes and dams yet to be built on the Ohio River that it is embarrassing to select those that should first receive attention. The following are among those most needed; they are named in the order of their distance from Pittsburgh:

Merriman, 10 miles below Pittsburgh.—This bar was once the most formidable of all the obstructions to coal-barge navigation. It is necessary to make a square crossing to the right bank, and nearly every run of coal paid toll to Merriman in the shape of one or more standard barges. In 1871 a contract was made for deepening and straightening this passage by dredging, and 3,799 cubic yards were removed. In 1872 the United States dredge Ohio removed 15,049 cubic yards, making a total of 18,849 cubic yards. As the result of this work the dangers of the passage were almost wholly removed, although the crossing still remained difficult.

Since then the isolated bar below the crossing, which acted as a dike to hold up the water, has been considerably reduced in height, and during coal-boat stages a large body of water, which is much needed in the channel, wastes over this bar. It would be injudicious to do any more dredging, and the only available remedy is the construction of a smooth deflecting dike, which will not only hold up the water, but will

also prevent boats from drifting on to the bar. This dike should be about 1,500 feet long, and its approximate cost would be $22,000.

Brown's Island, 60 miles below Pittsburgh.—The old dam behind this island, which was built in 1837, now requires repair. This work will cost about $24,000.

The Twins, 84 miles below Pittsburgh.—The dam closing the left-hand channel at the upper Twin should be raised, as too much water wastes through the back channel. This dam is 2,800 feet long. It was built in 1844, and was repaired in 1867, 1869, 1871, and 1872. It is wholly composed of riprap stone. Experience has shown that some more durable method of construction is a necessity, and it is therefore proposed to cap the existing low dam by a superstructure of crib work in the manner which has proved so efficacious at White's and the Trap.

The approximate cost of this superstructure will be $20,000.

The Brothers, 157 miles below Pittsburgh.—The dam from the left bank to the head of the middle Brother, begun in 1864 and left unfinished, should be completed. The addition will be about 2,200 feet long, and the total cost will be about $15,000.

Sand Creek, 219 miles below Pittsburgh.—A dike 1,200 feet long is needed to confine the channel over the bar. Estimated cost $18,000.

Twelve Pole, 311 miles below Pittsburgh.—This is a particularly objectionable bar, as it occurs 5 miles below the western terminus of the Chesapeake and Ohio Railroad. A dike 2,200 feet long from the Ohio shore would improve this well-known sticking place. The estimated cost of this dike is $33,000.

Medoc, 485 miles below Pittsburgh.—A contract for improving this bar by a dike from the Kentucky shore was let in 1869. Experience has since shown that the dike should have been built on the Ohio side. As the present work does not accomplish its purpose, I would recommend that a dike be built from the Ohio shore, and that the existing dike be removed by dredging. A new dike, 2,000 feet long, will probably cost $30,000.

Gunpowder, 508 miles below Pittsburgh.—This is one of the worst bars between Cincinnati and Louisville. It is believed that a crib-dike from the Indiana shore, 2,500 feet long, would remedy the difficulty. Estimated cost $37,500.

Flint Island, 682 miles below Pittsburgh.—A dike extending downward from the foot of the island will improve the bad crossing at this place. It should be 3,500 feet long, and its approximate cost will be $84,000, or $24 per foot. The increase in cost per running foot over the dikes above Louisville is due to the shifting nature of the bottom, which scours to greater depths, and therefore requires additional protection.

Oil Creek, 683 miles below Pittsburgh.—This bar and the preceding are really one long bar. To improve the crossing at this place will require a dike 3,000 feet long, at an estimated cost of $72,000.

Puppy Creek, 743 miles below Pittsburgh.—This is now the worst bar below Louisville, the depth over it often not exceeding 2 feet. To improve it a dike 3,200 feet long should be built from the Kentucky shore. It will cost $76,800.

Scuffletown, 764 miles below Pittsburgh.—This bar was improved in 1832, but the work has nearly disappeared. A dike on the same side as the old dike, but differing somewhat from it in alignment, would probably remove the cause of complaint at this bar. Its length will be 3,000 feet, and its approximate cost $72,000.

Caseyville, 860 miles below Pittsburgh.—This bar is often the shoalest between Evansville and Cairo. I would recommend the construction of

a dike from the Kentucky shore, having an approximate length 3,500 feet, at an estimated cost of $84,000. It may be found necessary in the future to run out another dike from Battery Rock on the Illinois shore, but it is advisable to postpone this for the present.

Walker's Bar, 870 miles below Pittsburgh.—This bar was at one time the shoalest below Evansville, but the scraping done some years ago by the *Octavia* helped it greatly. It is desirable, however, that this bad crossing should be permanently improved. This can be done by building a dike from the Illinois shore 4,000 feet long, at an estimated cost of $96,000.

To provide for office expenses, the cost of engineering, inspection, &c., the sum of $25,000 will be needed.

Summing up the above, we have the following

ESTIMATE.

Davis Island Dam	$200,000
Snagging	25,000
Dredging	16,500
Removing rocks	5,000
Dams and dikes:	
Merriman	22,000
Brown's Island	24,000
The Twins	20,000
The Brothers	15,000
Sand Creek	1[illegible]
Twelve Pole	35,000
Medoc	30,000
Gunpowder	37,5[illegible]
Flint Island	84,[illegible]
Oil Creek	72,[illegible]
Puppy Creek	76,[illegible]
Scuffletown	72,[illegible]
Caseyville	84,[illegible]
Walker's Bar	96,[illegible]
Office expenses, engineering, inspection, &c	25,[illegible]
Total	95[illegible]

I would recommend that no special allotment be made for the Davis Island Dam, but that the title of the appropriation be "for the improvement of the Ohio River, including the Davis Island Dam." The object of such a wording is to authorize the Chief of Engineers to make such an allotment as will enable the engineer in charge to take advantage of all favorable opportunities, and to prosecute the work with energy and economy. All parties concerned in navigating the Ohio are agreed that inasmuch as the work has been begun it should be carried on with the utmost energy.

Money statement.

July 1, 1879, amount available	$339,109 50	
Amount appropriated by act approved June 14, 1880	250,000 00	
		$589,109 50
July 1, 1880, amount expended during fiscal year	234,479 98	
July 1, 1880, outstanding liabilities	3,648 78	
		238,128 76
July 1, 1880, amount available		350,980 74
Amount that can be profitably expended in fiscal year ending June 30, 1882		955,[illegible]

THE LA MULATIÈRE DAM ON THE SAÔNE AT LYONS.

DESCRIPTION OF THE NEW SYSTEM OF WICKETS ADOPTED FOR THIS DAM.

By A. PASQUEAN, *Engineer des Ponts et Chaussées.*

PREFACE.

LYONS, 1879.

The movable dam which we are now building at La Mulatière, near Lyons, is situated directly at the junction of this river with the Rhone. It had to satisfy certain special and difficult(1) conditions which led to the successive rejection of all the systems thus far tried or proposed. After five years of research we have succeeded in devising a new type of movable dam which seems to answer all the requirements of the situation, and which could be advantageously employed for all dams of high lift which require wide passes unobstructed by piers.

By a decision of March 31, 1879, the Minister of Public Works definitely approved of our system for the dam at La Mulatière, speaking of it in very flattering terms(2). We here beg leave to tender him our hearty thanks.

In order to be able to reply at once to the questions which have been addressed to us on the subject of this dam, we have summed up in this description the principal innovations which characterize our system, and the advantages which result therefrom.

DESCRIPTION OF THE NEW SYSTEM OF WICKETS APPROVED FOR THE DAM AT LA MULATIÈRE.

DEFECTS OF FORMER SYSTEMS.

In existing dams with movable wickets, the latter are lowered by means of a *tripping-bar* which slides on rollers fastened to the floor, and is moved by complicated machinery placed in the abutments of the dam, and in piers built in mid-river to receive it.

When this machinery is set in motion, the projections on the tripping-bar successively force the props into the runways of their corresponding hurters, and the wickets fall roughly on the floor.

This arrangement presents serious objections.

The width of a single pass is limited, at most, to from 130 to 160 feet, by the necessity of securing sufficient travel for the lugs on the tripping bar, (3)and suitable mobility for the apparatus required for throwing down. To obtain this width it even becomes necessary to let down the wickets in groops of two or three towards the last, and to use two tripping-bars, of from 65 to 80 feet each, acting in opposite directions on each one of the two halves of the same pass. Hence the impossibility of using this system on passes exceeding 160 feet, without dividing them

(1) See Note 1. (2) See note 12. (3) See note 2.

NOTE.—It should be distinctly understood that the system of movable dam proposed by us for the amelioration of the navigation of the Rhone has no connection with that which is the subject of the present pamphlet.

The system which we propose for the Rhone has been deduced from the high-bridge system of Tavernier, which leaves the sill entirely free for the passage of gravel, and which on this account is particularly suitable for the improvement of this river.

With this in view we made a study of two modifications. The first was the subject of an article under date of May 15, 1877. The second, which is more practical, is described in our general study of the improvement of the Rhone, of which the lithograph was dated August 15, 1878.

by *large intermediate piers*, which are dangerous to navigation when the dam is entirely down.

With the tripping-bar, the wicket, at the moment of tripping, falls violently from its full height to its blocks. This method of operating, then, in spite of the cushion of water formed by the lower pool, produces *violent shocks*, which are admissible for wickets of limited dimensions, but which would constitute a real danger for wickets of 3,500 to 4,000 pounds, falling on the floor from a height of from 13 to 16 feet. Moreover, these shocks absolutely prohibit the adoption of wickets entirely of iron, the use of which is more and more justified by the increased price of wood and the increasing height of projected wickets.

In the system now used, the lowering of wickets takes place in a *prescribed order*, and if a wicket refuses to fall, all the rest of the dam must remain up. If the dam is partly caught by the ice, it is impossible to lower the portion that is free, and thus reduce the fall so as to be able to disengage the rest.

The tripping-bar is a *frail and delicate member*, which complicates the dam with a great number of adjustments which are hard to make and hard to keep in order. If a stone gets between one of the lugs and the hurter, if a cap of ice forms on a wicket, we are forced to break the tripping-bar, and to give up opening the dam by this method.

All the parts are placed under water, or in wells inconvenient of access. Repairs and inspection by divers are difficult and dangerous.

DOUBLE STEPPED OR INDENTED HURTER.

We have overcome these disadvantages by the following improvement: The tripping-bar and its accessories have been entirely suppressed. The hurter, in front of the ordinary step, which we will call the *resting step (cran d'arrêt)* has a second step whose vertical face forms a very sharp angle with the axis of the runway.

This second step, we have named the *sliding step (cran de départ)*, and we call the whole hurter thus modified a *double-stepped hurter (heurtoir à deux crans.)*

The raising of the wickets takes place as in the ordinary system. The operator pulls on the breech chain until the prop falls upon the resting step. He is notified of this fact by the noise of the prop falling upon the hurter, or by the arrival at the windlass of a link marked for this purpose. It then only remains for him to slack off the chain by means of the brake in order to set up the wicket and close the corresponding part of the pass.

The lowering, on the contrary, is effected *in our system* in a manner *entirely novel* and *exceedingly simple.*

To lower the wicket it is only necessary to draw upon the breech chain until the wicket is swung; then continue the pull until the prop falls down its sliding step, and then slowly pay out the chain by means of the brake on the windlass. The prop *spontaneously directs its course towards the runway* by the action of the oblique plane forming the vertical face of this step, and the wicket falls gently upon the floor *without any sort of shock*, as if the hands of the lock-keeper had laid it down upon the blocks placed to receive it.

Our system of *double-stepped hurters* entirely does away with the tripping-bar and the inconveniences which accompany its use. Each wicket is entirely independent of its neighbors. It contains in itself everything required for manipulation, both for raising and lowering.

ADVANTAGES OF THIS HURTER.

Our system, then, presents the following advantages:

1. With the tripping-bar the *width* of a single pass is limited to 160 feet. To attain a greater width intermediate piers are necessary.

With our *double-stepped hurter* the pass can have *any desired width*, for, as each wicket contains its own working parts, it becomes possible to place many hundred of them in succession, one after the other, *without any intermediate pier*.

By means of this improvement the pass of the dam which we are now actually constructing on the Saône, at La Mulatière, near Lyons, will have a width of 340 feet, and, without any intermediate pier, it will include the entire free width of river between the lock and the dividing dike of Perrache. This advantage is keenly appreciated by boatmen on account of the exceptional length of the boats which frequent the Rhone, and of the pronounced obliquity of the La Mulatière bridge, a short distance above the dam, with the general axis of the river.

This peculiarity of our system could likewise be of great service in the dams now in course of construction on the rivers of North America, which are traversed by rafts of exceptional width, and also in the dams which will sooner or later be built on the great rivers of Europe, near their mouths, in the portions which are frequented by sailing vessels.

2. With the tripping-bar, lowering takes place roughly, and, near the end of the operation, by groups of wickets.

With the double stepped hurter it takes place *without any kind of shock*, and the wickets are led *by hand* quite down to the blocks placed to receive them. It then becomes possible, with this method of lowering, to build wickets considerably higher than 13 feet, and to use nothing but iron for the panels, as we have done with those of the dam at La Mulatière.

3. With the tripping-bar the lowering takes place in a prescribed order, and a single obstinate wicket may stop the whole operation. In our system the lowering can go on *in any order whatever*. If a damaged wicket requires attention, if the dam has been partly caught in the ice, it is possible with our hurter to lower all the free wickets, and to return to the others after having obliterated the fall by this partial lowering.

4. The tripping-bar is a *frail* and *complicated* member. The double-stepped hurter, on the contrary, is so simple and rustic that any chance of breaking or of injuring this part of the mechanism seems altogether improbable.

By thus suppressing the most delicate and the most inaccessible part of the wicket-dam, repairs and examinations will be more rare and less expensive.

5. With the tripping-bar we are compelled to build the whole pass simultaneously, in order to lay and test the tripping-bars which pass across its entire length. With the double-stepped hurter it becomes easy, by means of intermediate coffer-dams, to *divide into any number of parts* the construction of a pass, just as we are now doing with the dam at La Mulatière.*

6. With the tripping-bar, and the shocks which result from its use, it is impossible, or, at the very least, quite dangerous, to lower wickets of 13 feet under falls exceeding $2\frac{1}{2}$ feet.

With the double-stepped hurter the power required to lower wickets

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* See note 3.

of 14¼ feet under falls of 5 feet is much less than that which the windlass must be able to exert for raising. It then seems possible with this system to lower without danger wickets of large dimensions under very heavy falls.*

Besides, with our system it is possible to calculate exactly the power required for lowering, and the dimensions of the parts necessary to give such power; while with the tripping-bar it is impossible to foresee the strains to which it will be subjected, and which so often produce the rupture of this piece, in spite of the excessive weight which experience has gradually been compelled to give it.

7. With the tripping-bar the crest of the dam cannot be lowered except by inadmissible complications.

With our system of lowering it is very easy to add, below the resting step, a third step, by which we can give to the wicket at will a much greater inclination to the vertical, and can fix the crest of the dam at, say, 1½ feet below the normal level of the pool. To lower the dam *when held at the third step*, we have only to pull the wickets up to the sliding step, without stopping on the first resting step, and then to pay out the chain as in the first case.

We call this second resting step the ***reducing step*** (*Cran de réduction*), and the hurter with three or more steps ***indented hurter*** (*glissière à crémaillère*).

As a matter of experiment, we propose to apply the reducing step to some of the La Mulatière wickets.

8. In the preliminary project which we drew up for La Mulatière according to the old system, the tripping-bars with intermediate pier were estimated to cost $11,000. In our project as finally approved with double-stepped hurter, this expense is entirely saved.

Our system then effects a *marked economy*, aside from the other advantages which it presents.†

VARIOUS IMPROVEMENTS.

The wickets which we are building for La Mulatière have also the following improvements:

A. Experience with the Ile-Barbe dam shows that wooden wickets hardly last ten years, while the iron lock-gates at the same dam are yet entirely sound. We have therefore wholly excluded wood from our dam.

The panels of the wickets are 14.3 by 4.6 feet. They are formed of two bars of U iron 7¼ by ⅝ inches, brought within 2.95 feet of each other in order to reduce the length of the head of the horse. They are covered by $\frac{3}{16}$-inch plate-iron projecting 10 inches beyond the uprights, supported by brackets and stiffened at the edge by a 2⅜-inch angle iron. A casting forming a part of the counterweight answers for the fastening of the handle of the breech.

B. A flutter valve, 5 feet by 3, is placed in the chase to form a partial outlet, and to facilitate the regulation of the pool. It is held in place by a bell crank which has the necessary property of keeping it shut more and more firmly under increasing water pressure when the wicket is up, and also under the action of boats, or of the current when it is down. It is easily worked from the foot-bridge by means of a pole with a head like that of a cane, which is supported by a light derrick.

C. The old-style journal boxes of the horse with their wooden wedges are unsuitable for large-sized wickets. The journal boxes with screws

* See note 4.

† See note 7.

or keys, since tried or proposed, cannot be dismounted after a few months' immersion. We have got rid of these troubles by suppressing the lower axle of the horse. A Bessemer steel journal box with three checks receives the two lower eyes of the uprights of the horses of two adjacent wickets, and holds them by a steel bolt 2¾ inches in diameter, with washer and pin at each end. Even should there be a thick coating of rust and scale, it will always be easy to cut one of these pins with a chisel, and to dismount a wicket by driving out the bolt.

D. We have wholly discarded the old wooden sill, whose renewal was accompanied by serious difficulties. In place of it we use a cast-iron sill from 1¼ to 2½ inches thick, which will last as long as the floor itself.

E. At La Mulatière the wickets will be worked both in raising and lowering by a very small *steam-windlass* traveling on a service bridge. The same windlass will perform the four operations of lowering and raising the wickets and the trestles with attached flooring. By this means we can raise the dam in eight hours and lower it in four and one-half hours; that is, work the entire pass of 340 feet which we are building at La Mulatière.*

WIDE-SPAN TRESTLES.

The service bridge designed to carry the windlass presents the following innovations:

1. Up to the present time the trestles have been made to equal the wickets in number, and the *depth of the trench* necessary to shelter them when down has rapidly increased with the height of the bridge. At La Mulatière for a bridge raised 20 feet above the sill this arrangement would require trestles 23½ feet high, lying six ranks deep, and necessitating a trench 4 feet in depth, which would have increased to intolerable proportions the danger of silting up and the difficulties of working.

To avoid these inconveniences we have provided a *wide-span service bridge*, placing the trestles 9.8 feet apart, and opposite the even-numbered wickets. These trestles, when down, superpose in only three ranks, and thereby we have been enabled to reduce the depth of the trench to 28 inches, to diminish the chance of silting up, to increase the rigidity of the trestle while at the same time diminishing the total weight of bridge, and to reduce to 22.3 feet the total height necessary in order to have the flooring 19.7 feet above the sill.

2. The removal of the bridge-planks by hand and their transportation to a storehouse at every flood becomes impracticable with the weight they must have for dams of high lifts. We have therefore hinged each section of the flooring to the corresponding trestle, and each trestle carries down with it the part of the flooring which is fastened to it, an arrangement similar to that formerly tried on the Cher.

3. In the dams of the Cher each section of the flooring hooks on to the axle of the section that preceded it. The sections are longer than the intervals between the trestles, and each section finds itself caught under the succeeding trestle when the whole are let down on the bottom.

The *superposition of the sections of the flooring* therefore immoderately increases the depth of the trench, and causes the loss of what was here gained by the omission of the odd-numbered trestles.

In our system, at the top of each trestle are *two distinct axles*, spaced 13 inches apart, and serving, the one for the hinging of its section of flooring, and the other for hooking on the next section. The total length of section is reduced to 9.3 feet for trestles spaced 9.8 feet, and all the

* See Note 5.

sections *lie end to end* when down, with a clearance of 6 inches between them without being lapped by the adjacent trestles.

4. A guiding bar fastened to the windlass during the operation of raising receives the flooring just as it is about to strike the preceding trestle, and guides it, as if by hand, into the journal boxes arranged on this trestle to receive it. This same guiding bar prevents the end of flooring next the windlass from falling down as soon as the process of lowering is begun, and lets it down *without shock*, until, by its own weight, it naturally assumes a suitable direction for falling on the floor.

5. The up-stream beam of each section of the flooring, being the one on which the holding-down hooks of the windlass pull during the maneuver, cannot, like the lower one, be simply hooked on to the bolt of the preceding trestle. In our plan a T-shaped end insures the rapid coincidence of the eyes, and a *key* enables us at once and without fail to firmly fasten the upstream beam in the journal box of the preceding trestle.

6. The bottom axle of the ordinary trestle assembles badly with the channel iron upright. The cost of the dam is unnecessarily increased, and numerous attempts have been made at different times to lessen these difficulties. We have completely overcome them all by suppressing this axle. The trestles are finished at their lower ends by angle blocks, which are provided with eyes, and they are fastened by two independent bolts to double-cheeked pillow blocks embedded in the floor. These cast-steel bolts, 2¾ inches in diameter, have washers and pins, and it merely requires the cutting of the pins to dismount the trestle even after it has been a long time under water.

7. The trestles are built of 5½-inch channel iron, and are shaped like a double St. Andrew's cross, which gives them great rigidity in both directions. They are symmetrical.

8. The last bay of the service bridge is spanned by a rolling bridge, which is run back into the abutment with the greatest facility when the lock-keeper begins at the last trestle to lower the service bridge.

9. In the ordinary trestle the upstream upright is vertical, and is laid down lengthwise of a *vertical* chamber from 20 to 30 inches deep. When the dam is up gravel collects in this chamber, and it is necessary, as at Ile-Barbe, for example, to remove the deposit by a diver every time the trestles have to be lowered. In our plan, the trestles are symmetrical, their journal boxes are entirely in projection on the floor, and the latter is connected with the sill by a slope of 1 on 2, which is less steep than the natural slope of sand deposits.

With this arrangement there is every reason to hope that the trestle chamber will not silt up.

SUMMARY.

To sum up, our system of dam allows us—

1. To close passes of indefinite width by means of wickets, and without the use of an intermediate pier;

2. To put an end to all shock in lowering;

And, consequently,

3. To make wickets entirely of metal;

4. To provide in a practical manner for falls of from 12 to 20 feet, and even more, measured from the metallic sill of the floor.

It also permits us—

5. To work dams of large dimensions rapidly;

6. To avoid all transportation to storehouses;

7. To get rid of the principal causes of injury and of interference by sand and gravel.

NOTES.

Note 1.—*Special difficulties at the La Mulatière Dam.*—In an ordinary dam the rise omes from above. The dam can and should be opened gradually as the discharge icreases. It will thus be almost entirely down when the natural level of the rise aches that of the pool, or even a height somewhat lower, if the first obstruction to covered is so far up stream as to permit the water surface at the dam to be lowered moderate stages. In such a case it is possible to place the service bridge at only 20 iches above the level of the pool and to maneuver the dam slowly, since we have at ir disposal for that purpose all the time that the water level below the dam takes to ass from low-water to the level of the upper pool, or to its reduced level. The same ning holds for closing the dam when the water is falling.

At La Mulatière, on the contrary, the Rhone will almost always take the dam in reerse. The pass must remain entirely closed until the main river rises from the lowater stage to the level of the pool, and it will then be necessary to open the dam ery rapidly under penalty of having the service bridge submerged. So also it must ften be closed in a few hours before the main river drops below the level of the dam, order to prevent the pool from being suddenly emptied by a rapid decline of the hone.

Moreover, the obstructions to be flooded are so near the dam that it is necessary to eep the pool constantly at its normal level without reduction, in order to insure at ll times the required depth of 8 feet.

Hence the necessity of placing the service bridge at 6.6 feet above the pool and of exluding all systems of dam for which eight or ten hours would not suffice to maneuver he whole of a pass 340 feet long and 13 feet above the sill.

Again, the La Mulatière dam is situated only 1,500 feet below the Saint Etienne ailroad Bridge, whose piers make the marked angle of 50 degrees with the general xis of the river. The river will be chiefly navigated by the immense freight boats of he *Compagnie Générale*, which are as much as 492 feet long, and which must make a harp turn after passing the bridge to get out into the Rhone by way of the dam.

To insure safe navigation, therefore, it is indispensable to reject all systems requirng piers in the river, and to leave the Saône entirely free over the 340 feet included etween the lock and the dike which separates it from the Rhone.

Lastly, it is necessary to give passage to a considerable discharge (which amounts o 29,065 cubic feet at 8.2 feet above low-water), to resist a current which sometimes eaches 7.7 feet per second, and to support a pool raised 13.1 feet vertically above the ill of the pass, and which will have a lift of 11½ feet when the dikes of the Rhone hall have reduced the minimum draught of water on the sill of the lock to 6½ feet.

For the floods of the Saône, therefore, the La Mulatière dam must answer all the emands of an ordinary dam built in a very rapid river, and it must also satisfy pecuiar and altogether novel conditions in fulfilling the special requirements arising from loods in the Rhone, which, in a few hours, may take the dam in reverse, without llowing any opportunity to commence working it until the rise from below reaches he level of the pool.

Note 2.—*Limiting width of former passes.*—The tripping bar must travel about 6 inches o trip a wicket 4 feet 11 inches wide, including clearance. It follows, therefore, that he projections should be spaced 4 feet 11 inches minus 6 inches, that is, about 53 nches apart, so as to lower the wickets in succession, and that with a single tripping ar it is impossible to lower more than nine wickets in succession, since the eleventh rojection strikes the tenth wicket at the same time that the first projection reaches the irst wicket. It is true that sixteen wickets can be lowered with one bar by separating he projections into nine groups, so as to lower the first four wickets in succession, the ext six in groups of two, and the last six in groups of three; but this extreme limit has not been exceeded, and it even seems that it cannot be reached at all without langer, in case the wickets are very high. As sixteen wickets of 4 feet 11 inches make 78 feet 9 inches linear, two tripping rods working in opposite directions must necessarily be used to close a pass 157½ feet wide, and it is not possible, with the system of lowering by tripping bars, to make passes exceeding 160 feet without dividing them up by means of intermediate piers.

Note 3.—*The construction of a pass by sections.*—To build the La Mulatière pass in two sections, and always leave half the river open, we work in the following manner:

The half of the floor in actual process of construction is closed at its end by the concrete bulkhead B. In this enclosure we expect to put in position the first half of the mechanism. We will then remove the wickets and the trestles for the last 20 feet, and build in their place, inside of bulkhead B, a clay bulkhead A, covering up the journal boxes and the hurters of the parts removed.

Next year we will complete the second section of the coffer-dam, connecting it with bulkhead A; we will then tear away bulkhead B in the dry, and beyond it we will find the last journal boxes which will permit us to go on with the construction in continuity with the part already laid.

After removing bulkhead A it will be easy, by means of a diver, to put back to their places the wickets and the trestles whose journal boxes were covered in under the bulkhead during the construction of the second section of the pass, and thus re-establish the continuity of the dam.

This method of construction was first suggested to us by conductor Givoiset, who superintends the work with equal intelligence and devotion.

Note 4.—Power required to throw down the dam.—In our system the maximum power required to lower a wicket is that required to put it on the swing. It is easy to calculate this power exactly in all possible cases, and to ascertain that it does not exceed the figures of the following table for the La Mulatière wickets, which are 14.3 by [illegible] feet.

To these figures must be added the weight of the chain, which is 111 pounds, and a tension of about 132 pounds, which is required to put the wicket on the swing when it is immersed in still water.

The maneuvering windlass required for the usual method of raising should easily develop a traction of 11,000 pounds.

It *is therefore evident* that, in our system, the power required for lowering is relatively very small, and that with this system it is possible to lower wickets of great dimensions under falls which would prohibit the lowering of the wickets by the use of the tripping bar.

Table.

Fall.	Pool at normal level (H = 13.12 feet).	Pool 1.64 feet below normal level (H = 11.48 feet).	Pool 3.28 feet below normal level (H = 9.84 feet).	Remarks.
	Pounds.	*Pounds.*	*Pounds.*	
0.33 feet	117	170	205	*a* 179 pounds for 0.9[illegible]
0.66 feet	*a*143	359	386	*b* 538 pounds for 1.31 [illegible]
0.98 feet	187	390	538	*c* 1,001 pounds for 1.[illegible]
1.31 feet	249	*b*538	....	Which are the actual [illegible]
1.64 feet	326	677	906	ences of level that [illegible]
1.97 feet	421	833	*c*1,096	cur at La Mulatière [illegible]
2.30 feet	611	1,005	1,292	extreme cases of [illegible]
2.63 feet	650	1,166	1,492	maneuvering.
2.95 feet	783	1,349	1,686	
3.28 feet	928	1,534	1,894	
3.61 feet	1,085	1,724	2,094	
3.94 feet	1,257	1,920	2,297	
4.27 feet	1,418	2,121	2,495	
4.59 feet	1,600	2,315	2,690	
4.92 feet	1,786	2,522	2,884	

Note 5.—Working time.—From experiments made with the La Mulatière wickets the time for handling the wickets, apparently, should not exceed—

In lowering	For one wicket	3 minutes
	For one trestle	2 minutes
In raising	For one wicket	5 minutes
	For one trestle	4 minutes

That is, for a pass of 340 feet, containing 69 wickets and 34 trestles, worked by the same windlass—

For lowering	4 hours 35 minutes
For raising	8 hours 1 minute

Note 6.—Calculation of stress.—According to the detailed calculations in the appendix of our report of December 21, 1878, the maximum stress per square inch in the different parts does not exceed the following amounts:

	Pounds.
Prop	1,5[illegible]
Upright of horse	3,4[illegible]
Head of horse	[illegible]
Bottom axles of horse	2,[illegible]
Upright of wickets	[illegible]
Upright of trestles	5,[illegible]
Axles of trestles	3,[illegible]
Foot-bridge	[illegible]

Note 7.—*Cost.*—All the metal work of the La Mulatière dam was contracted for May 2, 1879, at the following prices per pound, net:

	Cents.
Wrought iron	$4\frac{1}{3}$
Cast iron	$2\frac{1}{2}$
Bessemer steel	10
Chains	$6\frac{2}{3}$

The machinery is almost entirely finished, and weighs as follows:

	Pounds.
Wicket, with chain, bottom casting, and counterweight	4,846
Trestle, with floor, &c	3,933
Cast-iron sill, per wicket	1,267
Hurter	2,304
Journal-box for wickets	353
Journal-box for trestles	309

The total cost, including putting in place and painting with coal tar, will amount, for 340 feet, to $28,552.57; that is, per linear foot, $83.98, or, per square foot of discharge area, $6.40.

Note 8.—*Dam with traveling crane.*—We had at first designed to work the wickets by means of a traveling crane, 39¼ feet between supports, similar to those everywhere seen about railroad stations. The crane was to travel on two rails projecting above the floor, the one above and the other below the line of the wickets. The workmen, stationed on the crane, would propel it along with them by applying power to the driving wheels, and they would seize hold of the wickets by means of a boat-hook secured by a chain to a movable windlass on the traveler. The double-stepped hurter would be equally adapted to the raising or lowering of a wicket. By omitting the trestles, the dam would be much more simple and less expensive. A suspension bridge, or a trail ferry, could be substituted for the traveling crane.

We finally gave up the idea of proposing this arrangement for La Mulatière, as it would perhaps have seemed too venturesome for the first trial of our system.

Note 9.—*Patents.*—The double-stepped hurter and the other novelties described above have been patented in France and abroad. The patent taken out in France, at our own trouble and expense, is only designed to secure to the French state the free and gratuitous use of our system wherever it may think it advantageous to employ it.

Note 10.—*Maximum and minimum discharge of the Saône at its mouth.*—The discharge of the Saône at its mouth for any one height of water varies within wide limits, according as the Rhone is falling or rising.

To determine the minimum and maximum discharge of the Saône at the height of the pool (528.19), we examined the records of the past ten years, and noted the gauge readings at La Feuillée, which is 2¼ miles above La Mulatière, each time that the water surface reached the height of 528.19 on the gauge at the latter point. We thus found that the highest corresponding gauge reading at La Feuillée occurred January 24, 1873, and that the gauge at Neuville, 16 miles above, and beyond the effects of backwater from the Rhone, read that day 9.32, which corresponds to a discharge of 29,065 cubic feet.

As the greatest discharge of the Sôane at its mouth takes place when the river surface presents the greatest slope above this point, we concluded, from what precedes, that the maximum discharge of the Saône at the height of 528.19 is 29,065 cubic feet.

Note 11.—*Diagram of the differences of level during maneuvers.*—After having determined, by the above-mentioned method, the maximum and minimum discharges for a series of stages from low-water up to the highest navigable stage, we constructed the curves of maximum and minimum discharge of the Saône at its mouth, marking the heights of the water on the axis of ordinates. [See plate 3.]

We then calculated and plotted on the same sheet the curves of discharge through the dam—

1. When all the movable parts are up.
2. When the flutter valves of the wickets are entirely open.
3. When the upper gates of the weir are removed.*
4. When the lower gates of the weir are removed.
5. When the pass itself is completely open.

These calculations were made by varying the formulas according to the conditions

* The dam consists of a navigable pass of 340 by 13 feet high, closed by wickets with flutter valves according to our system, and a weir 260 by 8 feet, closed by two tiers of Boulè gates. The latter is almost at right angles to the pass, and discharges its waters into the Rhone.

of flow, and for heights of upper pool ranging from 4.9 feet below its normal level to 1.64 feet above.

This done, let us take any point, M, on any curve of discharge—that of the flutter valves, for example.

The abscissa of this point M m = 7,487 cubic feet, will be the discharge of the dam with all the flutter valves open, when the upper pool is held at the level corresponding to the ordinate M m'; that is, at 1.64 feet below the normal level of pool.

The vertical distance M P = 5.13 feet, between the point M and the corresponding point P on the curve of maximum discharge of the Saône, will be the maximum fall possible under the given conditions; that is to say, when the flutter valves are open, the pool being held at 1.64 feet below the normal level, and the Saône being in the most unfavorable condition for discharge.

Hence it follows that the simple reading of the curve suffitces to determine the conditions of fall and the manipulation required for any height of pool.

If, for example, the pool is held at the normal level of (528.19) the diagram shows that the horizontal line 528.19 cuts, the curve at the points *b c d e f*, and that it is consequently possible to regulate the pool:

	Cubic feet.
With the joint covers to the amount of	3,52[illegible]
With the flutter valves to the amount of	12,2[illegible]
With the upper gates to the amount of	21,9[illegible]
With the lower gates to the amount of	25,0[illegible]
With the wickets to the amount of	27,5[illegible]

It shows besides that the fall of 11½ feet is reduced by opening—

	Feet.
The flutter valves to	4.[illegible]
The upper gates to	1.7[illegible]
The lower gates to	0.[illegible]
The wickets to	0.[illegible]

It is also found by reading the intersections of the horizontal 524.91 with the curves that it is possible to hold the pool at 3.28 feet below its normal level under the following conditions:

By the flutter valves discharge, 3,325 cubic feet; fall, ——.

By the upper gates discharge, 5,297 cubic feet; fall, ——.

By the lower gates discharge, 11,301 cubic feet; fall, 1.80.

By the wickets discharge, 15,715 cubic feet; fall, 0.26.

This graphic method would be more simple yet, if applied to an ordinary dam where the lower pool always stands at the same level for a given level of the upper pool.

Note 12.—*Extract from the decision of approval, dated March* 31, 1879.

Monsieur LE PRÉFET: I have submitted to the examination of the general council of *Ponts et Chaussées* the detailed plan of the machinery for the pass and weir of the movable dam of La Mulatière, which is to be built at the confluence of the Rhone and the Saône.

This dam consists of ——— ———. * * *

The general council of *Ponts et Chaussées* were of opinion that the designs of the detailed plan of machinery for the pass and weir of the movable dam at La Mulatière seem perfectly to fulfill the exceptional conditions in which this dam is placed.

Many of the arrangements are entirely novel; they are very ingenious, equally simple and practical, and seem destined to introduce, not only in the construction, but also in the working of movable dams, improvements of great importance.

The council, moreover, has called attention to the great labor and the remarkable skill which have characterized the study of so difficult a question as that of the La Mulatière dam, and it has thought that the administration should express its satisfaction to the engineers, and especially to M. Pasqueau, the resident engineer, for the extended researches and the repeated experiments to which he has devoted his attention for many years in working out designs best adapted to the mechanism of this important work.

I approve in all points the opinion of the council, and I am happy, *Monsieur le préfét* to join in its commendation of the work of the engineers, and particularly of the studies of M. Pasqueau. * * *

Accept, &c.,

The minister of public works,

C. DE FREYCINET.

LYONS.

ESTLES.

Fig. 3. Elevation of th

9' 10"

C . Fig. 4. Plan.

8' 8½"

10

YONS.

ETS.

C.. Fig.15

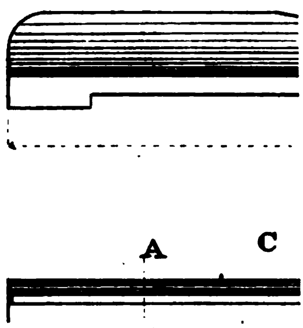
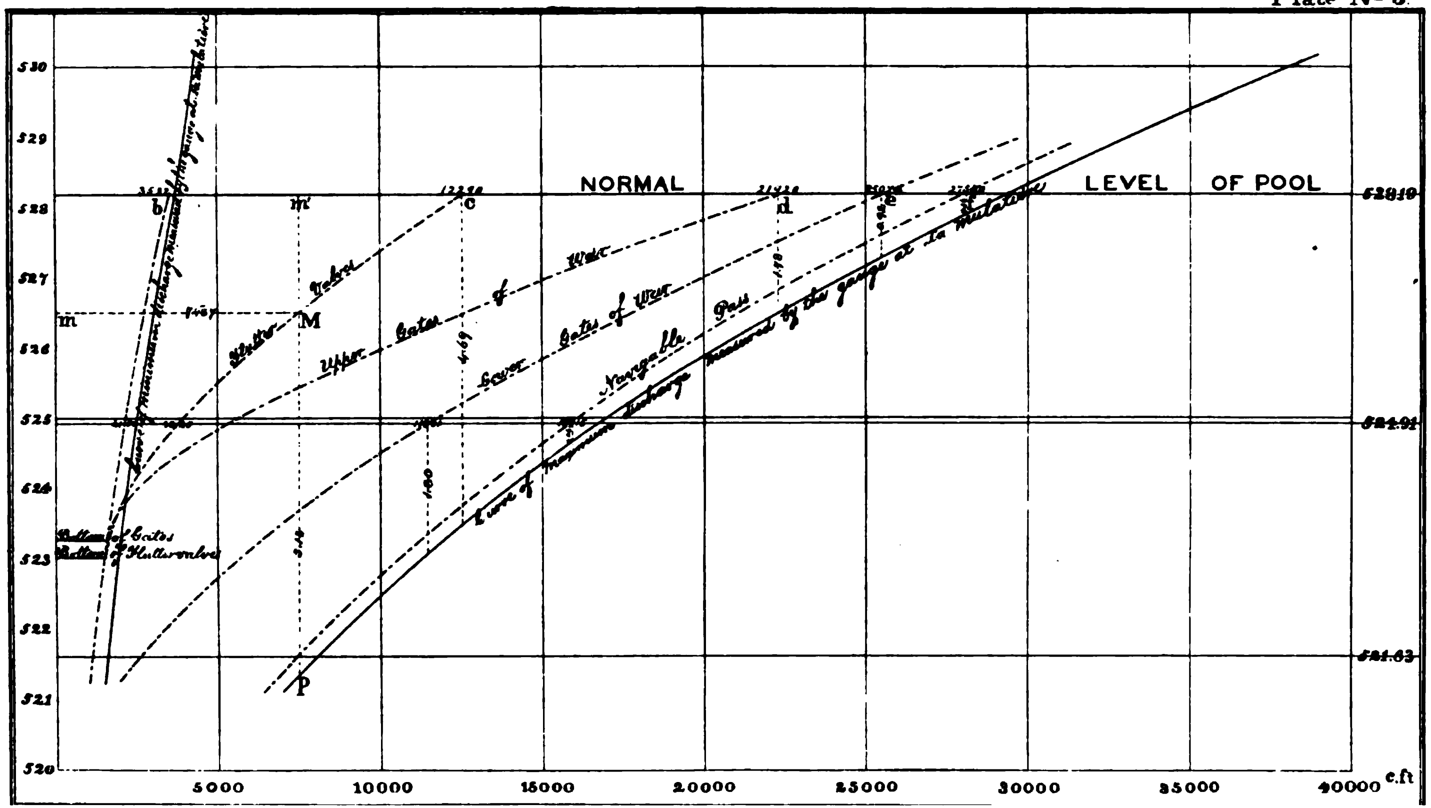


Plate No 3.



NORMAL LEVEL OF POOL
Upper Gates of Weir
Lower Gates of Weir
Navigable Pass
Curve of minimum discharge measured by the gauge at La Mulatière
Curve of maximum discharge measured by the gauge at La Mulatière
Bottom of Gates
Bottom of Shutters
b
c
d
m
m'
M
P
4.67
3.14
4.69
1.80
1.78
528.10
524.91
521.63
530
529
528
527
526
525
524
523
522
521
520
5000
10000
15000
20000
25000
30000
35000
40000
c.ft

X 2.

IMPROVEMENT OF MONONGAHELA RIVER, WEST VIRGINIA AND PENNSYLVANIA.

At the close of the last fiscal year the condition of the lock and dam at Hoard's Rocks, West Virginia, was as follows:

The lock was finished, except the miter and lift walls at the head, all of which had been purposely omitted, and the hanging of the gates and wickets.

The dam was about two-thirds done, the most difficult part of the work having been satisfactorily completed.

During the fiscal year just ended the whole work has been finished and the lock opened to navigation.

It may be worth noting that during the extreme low-water of last autumn, when the Ohio and all of its tributaries nearly ran dry, the pool of the Hoard's Rocks dam not only remained full, but had a steady overflow, although the combs of the dams below were 3 or 4 feet out of water, and all navigation through the lower locks was suspended; and this notwithstanding the fact that the Cheat River joins the Monongahela below Hoard's Rocks. This favorable result at such a time proves the wisdom of the advice of General Moorhead, the president of the Monongahela Navigation Company, that we should build the Hoard's Rocks dam of masonry instead of timber.

Owing to the fact that there are two dams yet to be built before the slackwater will be complete to Morgantown, the present structure is thus far of but little use to navigation, and passage through the lock has been limited to rafts and flat-boats.

The cause of this anomalous condition of affairs is fully set forth in my various annual reports on the improvement of the Upper Monongahela. I am happy to state that the appropriation of $25,000 made in the river and harbor act of June 14, 1880, for building a lock and dam near Laurel Run is the first step towards the construction of the missing link which will bring the work already finished into connection with the fine system of slackwater that has for many years so largely contributed to the development of the counties along the Lower Monongahela.

COMMERCIAL STATISTICS.

The only available commercial statistics are the annual reports of the Monongahela Navigation Company. All of the coal business of this company is done in the first four pools, as is also the greater portion of its remaining traffic. These statistics are not, therefore, applicable to the Upper Monongahela, but since there are no others, and inasmuch as the heavy traffic is steadily working its way up stream, the figures given are useful as an approximate measure of what may be expected in the future.

SHIPMENTS ON MONONGAHELA SLACKWATER IN 1879.

Coal, coke, and slack	bushels..	62,015,300
Classified freight	pounds..	42,583,450
Lumber	feet..	5,436,100
Timber	do ..	2,376,180
Brick		1,057,150
Steel rails	tons..	25,046
Iron ore	do..	2,405
Pig iron	do..	1,820

Fire clay	tons..	2,744
Whisky	barrels..	7,169
Oil in bulk	do....	3,654
Sand	bushels..	471,700
Stone	perches..	134
Wood	cords..	111
Staves		69,200
Posts		42,822
Sheep	head..	3,463
Hogs	do...	3,292
Cattle and horses	do...	376
Passengers		51,055

WORK DURING 1880–'81.

The first work to be done during the present season will be to purchase the necessary land for lock and abutments.

It is probable that as soon as this matter is satisfactorily arranged, s will be made for the delivery of the stone required for the lock.

ESTIMATE FOR 1881–'82.

The estimated cost of the lock at Dunkard Creek (near Laurel Run), as given in my last annual report, is $115,000, of which sum $25,000 was appropriated in the last river and harbor act. In work of this character, which can only be prosecuted during the brief and uncertain period of low-water, it is of the highest importance to have ample funds on hand in order to be able to take advantage of all favorable opportunities, and to thus reduce the cost of engineering and superintendence and the wear and tear of plant and coffer-dams. For this reason the whole of the estimated cost of the lock should be provided; and I therefore submit an estimate for the sum of $90,000, which is still needed in order to complete the original estimate.

Meanwhile it is necessary to provide for the working expenses of the lock at Hoard's Rocks, together with a small sum for making the running repairs that are always needed at such structures. For these purposes $2,000 will suffice. The estimate is, therefore, as follows:

To complete lock at mouth of Dunkard	$90,000
For running expenses of lock at Hoard's Rocks	2,000
Total for improvement of Upper Monongahela	92,000

Money statement.

July 1, 1879, amount available	$22,589 77	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$47,589 77
July 1, 1880, amount expended during fiscal year		22,589 77
July 1, 1880, amount available		25,000 00
Amount (estimated) required for completion of existing project		164,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.		92,000 00

X 3.

IMPROVEMENT OF THE ALLEGHENY RIVER.

The first appropriation for the improvement of the Allegheny River was made in the river and harbor act of March 3, 1879. The amount was $10,000, and it was expended as follows:

A dam of cribs filled with stone was built to close the right-hand

channel at Six-mile Island, 6 miles above the mouth. It turns water at the 3½-foot stage.

A riprap dam was built across the left-hand channel at Nicholson's Rapids, 35 miles above the mouth. It turns water at the 3-foot stage.

A sand-bag dam, for temporary use, was built at Garrison Ripple.

The channel at the mouth of the Allegheny was dredged out so as to allow light barges to pass from the Ohio and Monongahela into the Allegheny.

A crane-boat was purchased and equipped, and put to work removing rocks, snags, wrecks, and other obstructions. Her work may be summed up in the following table. The rocks numbered are only the large ones, no count being made of the small ones.

Locality.	Large rocks.	Snags.	Wrecks.	Old pier.
				Cub. yds.
Six-mile Island	11	1	......	....
Nine-mile Island	36	5	......	....
Fourteen-mile Island	14	2	......	....
Poketo Rapid	25	Nest..	1	....
Bull Creek Rapid	40	....	......	....
Thence to Jack's Island	60	....	......	....
Jack's Island	112	....	......	....
Kearn's Bar	90	1	......	....
Freeport	......	....	......	400
Murphy's Island	115	100	......	....
Total	503	109	1	400

A number of bad rocks at Oil City were removed by a special party. These undertakings used up the whole of the appropriation.

COMMERCIAL STATISTICS.

It is impracticable to give accurate statistics of the commerce of an inland river, as there is no public necessity that causes the compilation of accurate records. All that can be done is to give such facts as are accessible.

Mr. Thomas P. Roberts, assistant engineer in charge in 1879, reports as follows:

A steamer and fleet of barges carrying oil constantly plies on this river from the oil fields to Huntingdon, W. Va., whenever the stage of water permits. Several hundred thousand barrels of oil have been annually shipped by this route to Richmond, Va. Five other steamers are also regularly engaged in the oil trade from the Pittsburgh and Ohio River refineries to the oil regions, but the quantity of oil transported by them I have been unable to obtain. It is usual for a steamer to have three barges in tow, and they transport about 7,500 barrels at one trip.

It is estimated that the lumber trade, exclusive of railroad ties, &c., amounts to over 00,000,000 feet annually. Besides this, immense quantities of staves and finished barrels are annually transported on the river. The flat-boats specially engaged in this business are quite numerous.

The construction of "bottoms" for Ohio River coal-boats, and latterly, at Freeport and other points, of finished boats and barges, is a large industry, giving employment to many hands, saw-mills, &c.

The tonnage of the Pittsburgh coal barges and boats alone represents a greater carrying capacity than is owned by any city in America. These boats range from 400 to 00 tons burden each, and 3,000 of them are in constant use. It is a safe calculation to assume that 300 new boats are required every year, a large proportion of which come from the Allegheny.

A very extensive trade in limestone is also carried on to supply the furnaces at Pittsburgh, which alone gives employment to several hundred men. Considerable coal is

also shipped from point to point. Another item of importance is the trade in bowlders for street-paving purposes.

In short, the Allegheny up to and through the oil regions is a channel for a large and miscellaneous commerce of very considerable importance, aggregating in value at least $5,000,000 annually; and it is a channel very susceptible of improvement, which, if once effected, would greatly augment a commerce that now suffers much from the uncertainty of a reliable depth. The trouble is there is too much idle time for the boats in use, and the more this time is curtailed the greater the inducements will be for shippers to avail themselves of the river.

APPROPRIATION OF JUNE 14, 1880.

The last river and harbor act appropriated $20,000 for the Allegheny River. Authority to begin work was not received until after the close of the fiscal year.

It is expected that by December, when work must necessarily cease, the whole of this appropriation will have been expended in removing rocks and snags, and in building wing-dams and dikes.

ESTIMATE FOR 1881-'82.

The estimate contained in my reports of January 10 and January 20, 1880, for the improvement of the river below French Creek by means of dams and dikes and by the removal of rocks, amounted to $81,000, of which $20,000 was appropriated at the last session of Congress, leaving $61,000 yet to be appropriated. The whole of this sum could be advantageously used during the next fiscal year in continuing the work already begun.

For the Allegheny River above French Creek reference is made to my report of February 5, 1880 (Senate Ex. Doc. No. 89, Forty-sixth Congress, second session). The estimate therein contained for improving the river from French Creek up to Olean is $40,000, the whole or any portion of which could be advantageously expended during a single working season.

Several urgent letters have been received from business men of Pittsburgh, notably one from the Pittsburgh Chamber of Commerce, requesting that an allotment be made for the improvement of Garrison Ripple. This ripple is at the head of Herr's Island, and is about 2 miles above the confluence of the Allegheny and the Monongahela.

The upper boundary line of Pittsburgh crosses the Allegheny 8¼ miles above this confluence. This ripple, which is impassable in low-water, and lies in the lower half of the Allegheny Harbor of the city of Pittsburgh, practically cuts that harbor in two.

Pittsburgh is the chief town in the United States for all manufactures of iron or glass, and for many miles both shores of the Allegheny are lined with huge industrial establishments. It is therefore of the highest local importance that the shoal which prevents the free use of the river for the transfer to and from the mills of iron, coal, and other heavy freights should be removed as soon as practicable.

The only effectual way of doing this is to build a lock and dam in the vicinity of the Mechanics Street Bridge, as recommended in my report of March 9, 1876 (Report of the Chief of Engineers for 1876, part 2, page 149). The approximate estimate contained in that report was $153,000 for a lock 200 by 50 feet, attached to a permanent timber dam.

Neither time nor funds permitted locations and detailed estimates, but the approximate estimate can readily be replaced by one more nearly exact, should Congress adopt the plan by making a first appropriation.

Nothing else will answer the legitimate needs of the harbor of Pittsburgh, and inasmuch as the approaching completion of the Davis Island Dam, in connection with the dams on the Monongahela, will soon give all needed water in the Ohio, Monongahela, and Lower Allegheny portions of this harbor, it is only fair that something should be done for that part of the Allegheny Harbor which lies above the influence of the Davis Island Dam.

A dike might help matters somewhat, but the long shoal of Herr's Island lies just below Garrison Ripple, and therefore but little could be expected from such an improvement. The proposed lock and dam would wholly obliterate these shoals, and its beneficent effect would be felt up to the upper boundary of the city. As the proposed improvement is on the Allegheny River, it seems proper to introduce it into this report.

I therefore submit the following estimate:

For continuing the present system of operations on the Allegheny below French Creek by building dikes and removing obstructions	$61,000
For improving the Allegheny between French Creek and Olean, N. Y.	40,000
For improving the Allegheny Harbor of the city of Pittsburgh	153,000
	254,000

Money statement.

July 1, 1879, amount available	$10,000 00	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$30,000 00
July 1, 1880, amount expended during fiscal year		9,998 64
July 1, 1880, amount available		20,001 36
Amount (estimated) required for completion of existing project		111,000 00
Amount (estimated) for lock and dam in harbor of Pittsburgh		153,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882:		
For dikes and dams and removal of obstructions	$111,000 00	
For lock and dam in harbor of Pittsburgh	100,000 00	
		211,000 00

EXAMINATION AND SURVEY OF ALLEGHENY RIVER, FROM FRENCH CREEK (FRANKLIN, PENNSYLVANIA) TO OLEAN, NEW YORK.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, February 5, 1880.

GENERAL: I have the honor herewith to submit a report on the survey and examination of the Allegheny River between French Creek (Franklin, Pa.) and Olean, N. Y., which was ordered in the river and harbor act approved March 3, 1879.

The field work of the survey was intrusted to Mr. Thomas P. Roberts, assistant engineer, assisted by Mr. J. B. Dougherty. Mr. Roberts' report is hereto attached.

The distance from Olean to the mouth of French Creek, as measured along the river, is 132 miles; and in this distance the river falls 446 feet, which is an average rate of 3.4 feet per mile. The survey was made during the very low-water of the autumn of 1879, and the least water found on any bar or shoal was 6 inches. There are 79 bars upon which there was less than 1 foot of water. It is, therefore, evident that a depth of 1 foot in extreme low-water is all that can be expected from any system of improvement which is limited to wing-dams and dredging.

The most thorough and satisfactory method of improving this part of the Allegheny River would be to build locks and dams; but such an

improvement, if adopted, should begin at the mouth of the river, and should be extended upstream as it becomes self-sustaining from the development of an active and remunerative river commerce.

The Allegheny River is particularly well adapted to the use of slack-water, on account of its width and its abundant supply of water. The drawback is the frequency of gorges of heavy ice. How serious an obstacle the ice may be can only be determined after the endurance of one or more dams has been practically tested. It is probable that the increased depth that would be created by dams would have a very beneficial effect in reducing the destructive action of gorges.

As it is out of the question to discuss slackwater dams on the Upper Allegheny at the present time, it only remains to be seen whether cheaper expedients would secure such a return as would justify their trial.

It is believed that by a moderate expenditure, applied to the removal of rocks and the construction of low crib-dams and dikes, both the rafting period and the period of navigation by small tow-boats can be materially extended in the section in question. An addition of two months can probably be given to the two-foot navigation up to Warren. Above Warren there is at present no river interest except that of rafting; this may, however, be helped by the removal of rocks and by a few inches increase in the depth on the bars.

For the river between Oil City and Warren, Mr. Roberts submits an estimate of $30,500. I would prefer that the estimate should cover the whole distance of this survey, and I therefore increase it to $40,000. This amount will cover the 7 miles between Oil City and French Creek and will also admit of the removal of rocks, &c., in the section between Warren and Olean, for which Mr. Roberts makes no estimate.

* * * * * * *

Commercial statistics on inland rivers where there are no custom duties are occasionally preserved for special reasons, but they are never complete and are often far from accurate. Such as could be obtained on the portion of the Upper Allegheny which is the subject of this examination have been included by Mr. Roberts in his report. The chief items are 68,000,000 feet of lumber, 1,000,000 bundles of shingles, and 750,000 bundles of laths.

A map in 16 sheets accompanies this report.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF MR. THOMAS P. ROBERTS, ASSISTANT ENGINEER.

PITTSBURGH, PA., *January*, 18[illegible].

SIR: I have the honor to submit herewith the report upon the survey of the 1[illegible] miles of the Allegheny River between Olean, N. Y., and Franklin, Pa., which I made under your directions in August, September, and October last.

Having been assigned by yourself to take charge also of the improvement of the lower end of the river, which latter work required almost my constant attention, I was unable to be as much with the party in the field as I would have desired. I was quite fortunate, however, in securing the services of Mr. John B. Dougherty, assistant engineer, to conduct the survey as transit or compass man, who was assisted by Mr. James G. McFarlane as leveler. The means provided were of course too meager for a careful hydrographical survey of such an extent of river, complicated as it is with

islands, bars, and ripples, but the results obtained will be, I hope, all that is necessary for giving a correct knowledge of the general shape of the stream, its profile, its leading characteristics, its capability of improvement, and its value as a highway for commerce.

From Salamanca, N. Y., 23 miles below Olean, to Franklin, Pa., a distance of 109 miles, the survey was made when the water was lower than ever before known. During this time the fluctuations of the water surface were confined to a space of *less than 2 inches*.

This state of the river was extremely favorable, therefore, for obtaining with precision the length and descent of the ripples, many of which would be "drowned out" or be inappreciable even at moderately low stages in the river.

Having, in 1878, personally conducted a reconnaissance of the river, under your directions, from Franklin, the lower terminus of the present survey, down to Freeport, 93 miles, or to within 30 miles of its mouth, I will venture to make some reference to the river in general, for the purpose of setting forth in a connected manner some of the features of this important stream.

The name of Allegheny, which in New York is spelled Alleghany and Allegany, is derived from the dialect of the Seneca tribe of Indians, many of whom are still residing on the reservation along the river north of the Pennsylvania and New York State line. The word signifies "fair water." As the Indian word "Ohio" in other dialects also means "fair water," it is thought that the aborigines considered the two streams to be, as they really are, one and the same river. Were it not for the change in name at Pittsburgh, the Ohio would be stated in the tables as a river 1,292 miles long, instead of 967 miles, the Allegheny adding 325 miles to its usually accounted length.

SOURCE, AREA OF VALLEY, AND GENERAL COURSE.

The Allegheny heads in Potter County, Pennsylvania, interlocking with the headwaters of the Susquehanna and the Genesee. It is said that rivulets in that county, from a spot less than 1 square mile in area, discharge their waters into streams flowing respectively to the Chesapeake Bay, the Gulf of Saint Lawrence, and the Gulf of Mexico.

The area of the basin of the Allegheny is about 13,000 square miles, making at Pittsburgh very nearly two-thirds of the total area drained by the Ohio at that point. After a meandering course of about 55 miles through Potter and McKean counties, Pennsylvania, the last 15 miles of which are due north, it enters the State of New York in Cattaraugus County.

From the line it continues its northward course 6 or 8 miles farther, thence it turns almost due west to Olean, about 70 miles below its headwaters.

Below Olean it continues its western course to Salamanca (23 miles), from which last-mentioned point it takes its final southwest course to Pittsburgh.

PROFILE, FLOODS, BOTTOM LANDS, &C.

It is a somewhat singular circumstance that for a considerable distance the headwaters of the Allegheny have a less fall per mile than the main portion of the stream farther down.

For 25 miles above Olean it is stated to have a descent averaging less than 2 feet per mile. Below that point, in the first 20 miles, our levels show that its descent is at the rate of 1.7 feet per mile.

In this comparatively flat portion of its course, the river flows through extensive bottoms measuring in places a mile on each side to the foot-hills. These bottoms are in parts subject to overflow, even with rises of 10 to 12 feet; which, if not effecting much damage to property, as such places remain uncultivated, at least fill up the sloughs and make impassable morasses. The high-water of 1873 rose 15.8 feet at Olean, or about 6 feet higher than the ordinary banks of the river. Considerable portions of these bottoms, between Olean and Salamanca, rise in terraces above the flood lines, and are in a high state of cultivation, producing hay principally, with grain and fruit, particularly apples, in great abundance.

This upper portion of the Allegheny Valley is in every respect different from the country below. I am of the opinion that it was once a shallow lake, similar in some respects to the adjacent long, narrow lakes of New York, which, by a general subsidence in a southerly direction, was drained out.

The hills for the first time converge on the river banks at Corydon, Pa., just below the State line. Near that point there is some evidence of a gorge which might have been the original outlet of the lake. There is quite a sudden change in the profile of the river from the 20th mile point below Olean (just above Salamanca), the second 20 miles descending at the rate of 3.7 feet per mile. The third 20-mile division falls at the rate of 5 feet per mile.

The bottoms, with the exception noted at Corydon, to near the 60th mile, uniformly remain from ½ a mile to 1¼ miles wide from hill to hill.

At the 77th mile the hills finally converge on the river banks, and thence to the mouth of the Mahoning River, 123 miles, they follow the stream quite closely, leaving only occasionally any regular bottom land. The exceptions are found only at the mouths of large tributaries. The absence of bottoms for so long a distance is a striking feature of this river.

As the valuable reports of Gen. G. K. Warren have invested with much interest his hypothesis of a continental subsidence, and the attendant disappearance of certain lakes, I will add that the curious may find in the valley of the Conewango, a large tributary, as well as along the Allegheny itself, local evidence of some such action begun in the past, and possibly, as General Warren surmises, still continuing.

The Conewango flows south for about 20 miles parallel with the course of the Allegheny, which lies a few miles to the east, but separated from that stream by a high, broad range of hills or uplands. Its valley for much of this distance is very wide, but, judging by the eye, its water appeared to be exceedingly sluggish, apparently ponded back for miles. Such is, however, by no means the case with the adjacent portion of the Allegheny, which falls, as before said, in this part at the rate of 5 feet per mile.

I can offer no explanation of this want of parallelism in the planes of these adjoining valleys. It will suffice to have called the attention to the possible lacustrine origin of these extensive flats.

The following is a condensed statement of the fall of the river from Olean to Pittsburgh, beginning at Olean:

	Feet per mile.
First 20 miles	[illegible]
Second 20 miles	[illegible]
Third 20 miles	[illegible]
Fourth 20 miles	[illegible]
Fifth 20 miles	[illegible]
32 miles to Franklin	[illegible]
Franklin to Pittsburgh, 123 miles	[illegible]
Average, Olean to Franklin, 132 miles	[illegible]
Average, Franklin to Pittsburgh, 123 miles	[illegible]
Average, Olean to Pittsburgh, 255 miles	[illegible]

The table of ripples at the end of this report gives the elevation above mean ocean level at nearly every mile above Franklin.

CHARACTER OF RIVER-BED, ICE-GORGES, &C.

From what has been said of the differences existing in the characteristics of the different portions of the valley of the Allegheny, it is natural to expect that the river itself would not have the same regimen throughout; and it certainly has not. From Olean to Jamison's Falls, 27¼ miles, the river meanders through its wide valley, having a sandy or fine gravel bottom and an average width of 300 feet. At the Falls a few rocks and small bowlders make their appearance for the first time in the bed of the stream, but below that point, for 35 miles more, we find the former characteristics of soft bottom, the most notable exception being at Limestone Falls, 41¼ miles down. Here there is a solid ledge of limestone underlying the river-bed, and the descent is 3.84 feet in a distance of 650.

Throughout these 60 miles the pools between the rapids are shallow, rarely exceeding 5 feet in depth. Thence to Warren, at the mouth of the Conewango (67 miles) more loose rocks are observable. Below the Conewango, the river at ordinary stages is [illegible] feet wide, the pools varying in depth from 6 to 10 feet or more, and the rocks which have fallen from the hills, or have been pushed out by the tributaries, gradually increasing in number and size in the channel and along the shores. From Tionesta, [illegible] miles, to Pittsburgh, rocks are seldom absent from the shoals, often lying partially buried in the gravel, and proving dangerous obstructions to navigation.

Below Franklin the pools gradually deepen to 14 feet or over, and average a mile in length. Some of the pools are 25 feet deep at the very lowest stage. The waters of this river are naturally so clear that I have frequently seen the bottom where it was [illegible] feet deep. The beds of some of these lower river pools are composed of large fragments of rocks, varying in dimensions from 1 to 20 cubic yards, lying irregularly over each other. [As they form excellent building material it might be cheaper to raise these stones than to work the quarries on the hillsides.] At several places I was struck with the fact that so little small stone or gravel occupied the interstices of these rocky bottomed pools. As such pools sometimes occur between shores which are hard or rocky, the query arose as to how the large and sometimes shifting gravel and bowlder bars at their lower ends were maintained; not only maintained, but occasionally observed to be enlarging in area and increasing in height. Certain velocities will

doubtless hold in suspension certain sized particles of sand, gravel, &c., but I can scarcely conceive that bowlders, 5, 6, and 10 inches in diameter, are transported by the current over these deep pools. According to the theory of suspension we should expect that some of them would be caught by the bottom eddies and thrown down into the deep receptacles between the rocks referred to. We must, however, recognize the fact that these bowlders *do* travel, year by year, gradually down the stream. I venture to offer the following explanation of this phenomenon, if it may be so called.

The Allegheny River is peculiarly subject to hard freezes, ice-gorges, &c. In the neighborhood of Franklin and Oil City clear ice sometimes forms 30 inches thick. In the breakups which may happen when the weather becomes mild, the ice is no sooner in motion than gorges form at some of the shoals or in the narrow bends. The motion once checked the ice immediately piles up and a temporary dam is formed, raising the water several feet, and forcing the ice high up on the banks. Eventually the gorge moves, though it sometimes happens that colder weather will set in before it starts, in which case the fragments of stranded ice left behind, piled up on the bars and along the shores above the fast receding water line, become congealed in solid masses, holding in their embrace the bowlders, gravel, and detached rock on which they rest. Finally a flood of sufficient height arrives, and these minature ice-barges (often drawing 10 feet of water) find themselves in the stream. Being, as I have supposed, weighted with stone below their center of gravity, they will not turn, but float over the deep pools, parting with their stony freight only by attrition with the river-bed on the shoals; hence the growth of these bars. (This shore ice when starting frequently carries off large trees, which it drags out, roots and all.)

The Allegheny River is, I think, more subject to ice-gorges than any of the other tributaries of the Ohio. The extremely cold winter climate of the elevated regions about its headwaters, its rapid descent causing great velocity of current, the suddenness of its floods, and the number of its short bends, all conspire to make it remarkable in this respect. I allude so fully to this subject because I believe it a matter of the greatest importance, as affecting any plans which may be proposed for the improvement of the river.

Reliable accounts of these ice-gorges changing the channels, washing away bars and islands, and occasionally rebuilding them elsewhere, are difficult to obtain; but that such effects, due to such causes, are often witnessed on this river cannot well be doubted.

At Kinzua, in the upper wide bottom-land region, 54¼ miles below Olean, an ice-gorge some years ago dammed the river up, and caused it to flow in a circuitous route a mile or more through the bottoms, where it washed off the soil of cultivated fields and caused much damage to property before finally returning to the channel.

Another and more remarkable gorge happened in the month of January, 1877, within the city limits of Pittsburgh, opposite Fiftieth street (about 4¼ miles above the mouth of the river). Fiftieth street, prior to that winter, terminated about midway of the pool, 2 miles long, between Six-mile Island and Garrison Ripple. This pool was from 1,000 to 1,100 feet wide, the normal width of the lower portion of the river, and in 1868, when I had occasion to sound it, was 10 to 14 feet deep.

The pool was somewhat bowed or crescent-shaped on an arc of great radius, practically straight. On this occasion the Allegheny broke up at a stage of only 5¼ feet, while, on the other hand, the Monongahela was in a flood stage, and there is no doubt that it ponded back the Allegheny and checked its current considerably above Fiftieth street. When the gorge formed in this place the bed of the river for 10 miles above became entirely choked up with ice piled to the height of between 25 and 30 feet, covering the bottoms in places. It remained intact for several weeks, during which period the pent-up water excavated outlets for itself beneath the ice. The effect of these powerful jets of water was to dig up and carry away the gravel from the bed of the river from a half mile above Fiftieth street, and deposit it in the form of a bar in mid-river below the gorge. This bar and shoal, containing 6 to 8 acres, yet remains, its top showing above low-water surface. This, then, is a case of a bar and shoal being created where before there was deep water and a fine, wide channel. The quantity of ice held by this gorge may be approximately estimated at 25,000,000 tons.

There are a number of exceptions along this river to the general rule of the deepest water appearing in the bends. At some places, where there are islands, the channel in the bends is entirely dry at low-water, being choked up with gravel two or more feet above the water surface; while the low-water course is seen struggling among rocks and approaching the convex shore. The reason for these exceptions to the rule can, I think, be only properly ascribed to the action of ice-gorges. These form more solidly in the bends, being drawn there with most violence by the high waters usually attending the breakups. The weaker ends of these ice dams first break, or are undermined, and thence results the formation of a channel along the convex shore into which the low-water naturally draws.

Such being some of the effects produced by the almost irresistible agency of ice in this river, the engineer, in proposing plans for its radical improvement by the use of

either movable or permanent dams, will be called upon to provide extraordinary means for their security, and for the permanent maintenance of a navigable depth in their pools. The future must of course take care of itself, but I have thought in view of the damage annually done to steamers and to other craft by ice from this river, which is the heaviest that reaches the Ohio, that it would be quite practicable, and possibly advisable, to construct severable movable dams at intervals to Oil City, with several others on the Kiskiminetas, the Clarion, and the Red Bank, for the sole purpose of being maneuvered during the winter with the object of preventing hard freezing. The lowering of these dams would, I believe, create flood-waves sufficiently strong to break up and carry off the ice. If one of the dams near Pittsburgh was made a permanent structure, its overfall would tend to further break up the ice-fields and make the pool of the Davis Island dam a much safer harbor of refuge for the thousands of barges and steamers which will seek it after the completion of that important improvement.

BRIDGES AND OTHER ARTIFICIAL OBSTRUCTIONS TO NAVIGATION.

Special reference to the obstructions to navigation on this river in the shape of low bridges with short spans, the result of injudicious State legislation, having been made in your report of last year (Ex. Doc. 21, Forty-fifth Congress, third session), I append herewith a tabulated statement of these structures, from which it becomes evident that the language employed was amply justified by the facts.

In the column of channel widths a deduction in every case for the bridges below Warren should be made of at least 30 feet to allow for the thickness of piers and the riprap thrown around them. The measurements here given are from center to center of piers.

Tabulated statement of bridges crossing the Allegheny River in New York and Pennsylvania below Olean to Pittsburgh.

Place.	Distance below Olean.	Total length.	Number of spans.	Length of channel-span between centers of piers.	Height in clear above low-water.	Character of structure.
	Miles.	*Feet.*		*Feet.*	*Feet.*	
Olean, highway	0.0	240	3	80	16.5	Iron truss.
Warren and Bradford Railroad	1.3	300	3	100	20.0	Wood, Howe truss.
Allegany, highway	4.4	400	4	100	19.4	Iron, bow-string girder.
Vandalia, highway	10.4	290	3	150	15.2	Wood, Queen truss.
Erie Railroad, Bradford Branch	14.7	185	1	185	14.4	Wood, Howe truss.
Tuna Creek, highway	15.1	320	4	104	26.0	Wood, Queen truss.
Salamanca, highway	23.2	405	5	85	19.2	Mixed trusses.
Little Valley Creek Island, highway	25.0	643	4	118	20.0	Iron, bow-string girder.
Red House, highway	31.0	410	3	132	21.0	Combination—wood and iron.
Quaker Bridge, highway	36.8	300	4	75	17.5	Wood, Queen truss.
Warren, highway	67.3	452	1	452	24.4	Suspension.
Philadelphia and Erie Railroad	67.9	450	3	150	18.6	Covered wooden truss.
Tidioute, highway	89.7	536	2	268	27.8	Suspension.
Tionesta, highway	104.4	435	4	120	25.5	Iron, bow-string girder.
Allegheny Valley Railroad	124.6	450	3	150	29.0	Covered wooden truss.
Oil City, highway	124.8	1,100	6	200	29.0	Do.
Do	125.0	700	3	500	41.0	Suspension.
Franklin, highway	132.1	711	4	175	31.5	Open wood and iron truss.
Blue Rock, highway	133.2	*700	4	*175	27.0	Wooden truss, new (1879).
Scrubgrass, railroad	148.3	471	3	157	22.7	Howe truss, wood.
Emlenton, highway	165.6	456	2	228	34.0	Covered wooden arch.
Parker, railroad and highway	172.1	790	4	197	34.5	Iron, bow-string girder.
Brady's Bend, railroad	185.7	750	4	200	35.7	Howe truss, wood.
Kittanning, highway	210.3	900	5	180	32.7	Iron, bow-string girder.
Freeport, railroad	225.6	795	5	185	38.0	Decked wooden arch.
Sharpsburg, highway†	249.9	905	5	181	38.0	Open iron truss.
Forty-third street, highway†	251.8	980	4	244	37.0	Covered wooden arch.
Sixteenth street, highway†	253.9	840	4	210	39.0	Do.
Railroad†	254.3	1,167	9	152	38.0	Iron lattice truss.
Ninth street, highway†	254.5	1,044	5	209	39.0	Covered wooden arch.
Sixth street, highway†	254.7	1,036	4	346	37.0	Suspension.
Point, mouth of river, highway†	255.2	1,060	5	212	40.0	Wood truss with arch.

* Estimated. † Pittsburgh.

In addition to the above, there are a number of ponton bridges maintained in the upper portion of the river in the State of New York, but they allow rafts to pass in times of freshets. No other navigation exists or is at present contemplated on that part of the river, so that these ponton bridges, as well as the low bridges above Warren, can probably be tolerated for many years to come. A steamer once actually ascended the river from Pittsburgh to Olean, but it must have been before the days of bridges, as no boats are constructed low enough to pass under several of the bridges above Warren. A height of at least 25 feet at Olean, 35 feet at Franklin, and 40 feet below that point, should in my opinion be given to bridges on this river.

Next to the bridges, the rivermen complain most of the refuse from oil refineries and acid works which is permitted to be wasted into the river. The oil refuse is a tarry substance which contaminates everything with which it comes in contact. It does great damage to the rafts of sawed lumber, and even the shingles piled on the rafts are frequently damaged by this substance being dashed over them by the waves of passing steamers. The horses employed by the guyper men in the seasons of low-water, in towing their boats of limestone, staves, barrels, &c., become smeared with this tar: while at other places the unfortunate animals have their legs cut with the acid. This acid (refuse of vitriol), diluted as it is in the river, still accumulates in places sufficiently concentrated to disintegrate the fibers of cables, which frequently break as though cut with a knife. For a long distance below one of these manufactories it is unsafe to bathe in the river. The case of a loss of life from this cause was reported last year as occurring at Oil City. It certainly is a gigantic nuisance to which thousands can testify, and which should be abated. As the oil refuse will burn, it could easily be destroyed in that way.

Many rivermen have called my attention to these annoyances, with the hope, I suppose, that mentioning them in a report might aid them in securing them relief.

Many years ago a high and low water line was established by the city of Pittsburgh, beyond the outside limits of which it was forbidden to extend embankments. But notwithstanding the ordinance many establishments persist in building out with their furnace clinkers obviously beyond the prescribed limits. Pipe lines for the conduit of oil laid in the bed of the river occasionally obstruct the low-water navigation. These examples, however, will suffice to show the need of an efficient revision of affairs on this river for the public benefit. No unity of action can be expected from those interested in the navigation. The individuals concerned are groping in the dark and feel that they have no legal status, and will continue to feel so until more specific legislation establishes their rights. A case in point will illustrate the vagueness of the knowledge which even officials have in regard to the rights of navigators. A furnace company in 1878 persisted in throwing red-hot cakes of cinder, the pieces often being the size of one-half cubic yard, over the bank, where they rolled down to the water's edge. Horses in towing boats past this place were often severely burned (I believe some of them died). The owners made complaint at the custom-house. They were referred by the officials there to the mayor of the city, who desired to know whether the furnace company was filling out on their own property or beyond the line where the jurisdiction of the United States is supposed to begin. As this point could not be settled, nothing was done until members of the Oil Exchange remonstrated and secured relief for the boatmen.

TRADE AND COMMERCE OF THE ALLEGHENY.

The rafting of lumber, as before said, is the sole business done on the river above Warren. Below that point steamers occasionally use the river for the transportation of coal, &c., in flat-boats, to the Venango County, Pennsylvania, oil regions. The transportation of oil by rail and by pipe-lines has effectually destroyed the river shipment of this extensive article of commerce, except for that portion destined for the Ohio Valley, or which seeks the favorable competing outlet from Huntington, on the Ohio, via the Chesapeake and Ohio Railroad, to Richmond, Virginia. A powerful steamer and fleet of bulk oil boats, each boat carrying 2,600 barrels or 7,800 for the fleet, makes constant trips up the river to Parker's and elsewhere, whenever the water will permit. The proprietor of this line assures me that a large increase in the trade would result from the improvement of the river, particularly by the removal of the dangerous rocks which cause them to withdraw, while there may otherwise be for weeks a reliable depth in the channel. Besides this line, five other steamers are engaged in the trade from the oil regions to Pittsburgh and Wheeling.

The miscellaneous business transacted on the river near Pittsburgh is very extensive, particularly that which is connected with the large barrel factories, and also with the work-house, 9 miles up. The superintendent of the work-house calculates that their direct loss is over $50 a day, when they cannot receive their staves and deliver their barrels by boat, which mode of shipment is always preferred to the railroads. The furnaces at Pittsburgh, chiefly located on the Allegheny, consume annually thousands of tons of limestone, which is brought to them in barges from above.

The honorable Harry White, member of Congress, has estimated the quantity of lumber annually transported down the Allegheny to Pittsburgh at 200,000,000 feet, not including staves, &c.

The following are the statistics of the lumber trade of the portion of the river covered by the survey; they were obtained from the mill-owners at the various points designated:

Tabulated statement of sawed lumber and other products of timber shipped annually by the Allegheny River.

Name of place.	Miles below Olean.	L mber.	Shingles.	[illegible]
		Feet, B. M.	*Bundles.*	*Bundles.*
Olean*	0.0	7,000,000	100,000	[illegible]
Salamanca	23.3	5,000,000	100,000	75,[illegible]
Corydon	46.2	6,000,000	55,000	40,[illegible]
Kinzua Creek	56.4	8,000,000	60,000	50,[illegible]
Warren	66.8	2,000,000	20,000	15,[illegible]
Tidioute	89.8	7,000,000	300,000	200,[illegible]
East Hickory Creek	96.4	9,000,000	80,000	120,[illegible]
Tionesta	104.4	20,000,000	200,000	100,[illegible]
Hemlock Creek	112.0	4,000,000	60,000	40,[illegible]
Total	....	68,000,000	975,000	[illegible]

* Olean and above.

There yet remain to be developed valuable quarries of building-stone, of limestone for furnaces, and of glass-sand, mines of coal and of iron ore, and thousands of acres of hemlock timber, the bark of which is extensively used for tanning.

The market is near, but the extensive development of such natural resources must await cheaper transportation, which can only be obtained by an improved river.

PROPOSED METHOD OF IMPROVEMENT—ESTIMATE OF COST, ETC.

The proposed system of improvement in view of the present commerce to be benefited, which, though considerable, is still relatively limited, which I recommended last year, viz, the removal of rocks from the channel and the consrnction of wing-dams at the shoals, still appears to me the most advisable. It is a cheap system, but one which meets the present demands and which in time will create the necessity for a better method.

I have, in the general description of the river above Warren, designated a number of places which could probably be improved by the construction of wing-dams, but as the lumber trade is gradually declining new industries above that point must arise before, in my opinion, any considerable expenditure would be justified. It would be proper, however, to make an exception of the case of the dam at Corydon, Pa., near the State line.

At that place certain saw-mill owners have erected a crib-dam *entirely* closing the river, the descent over which is 3½ feet. At some stages rafts passing over the dam dip their heads so as to strike the bottom, and in consequence many have been broken up and destroyed. The upper rivermen have been persistent in their efforts to have this dam removed, or so modified as to permit them passing it with a greater degree of safety, but so far the local courts have not found a way to afford the raftsmen any relief.

There may come a time, also, when it will be desirable to radically improve the river to Olean in order to take advantage of the remarkably low summit existing between the Allegheny, near that point, and the waters of the Genesee River. The Genesee Valley Canal, constructed by the State of New York, but recently abandoned, connected the Allegheny River via this route with the New York and Erie Canal at Rochester. The distance via the canal to Rochester is 107 miles; distance from Olean to the summit level 14 miles; to reach which six locks only were required, overcoming a lift of 67 feet. From the summit to Rochester the descent is 980 feet, but as 301 feet of this fall occurs in one division of 12 miles and 530 feet of it in another section of the same limited length, it is quite probable that hydraulic inclined planes, such as you proposed for the Trans-Allegheny Canal (see Report of Chief of Engineers, U. S. A., 1876, vol. 2, p. 82), could be resorted to as a means to avoid the delays attending

excessive lockage. The water-supply at the summit, I understand, can be considerably enlarged.

There is depth of at least 3 feet in the channel of the Allegheny to Warren on an average of 100 days in each year, and a depth of 2 feet on an average of 130 days. In 1878 I showed by the records kept at Oil City, 57 miles below, that the removal of rocks and the construction of wing-dams would add about six weeks to the duration of a 2-foot stage to that point. We may with safety assume that the improvement will add one month of 2 feet water (the least practicable depth for steamboats) to the duration of navigation to Warren, thus making an annual navigation of 160 days. It must be borne in mind that the 130 days during which the river is now navigable cannot all be relied on, as the presence of rocks practically cuts off from safe navigation all the time that the river is actually below a depth of 3 feet. In effect, therefore, the improvement will add fully two months to the period of each year, during which steamers and barges can ply on the river as high as Warren. This much secured, the bark industry and others to be benefited could be managed in the same manner as the coal trade from Pittsburgh, which keeps relays of boats, some of which are always at the mines in readiness to depart whenever a rise comes.

In selecting places for improvement I have paid no attention to shoals or ripples which have naturally 1 foot depth, and are otherwise clear of obstructions. It is not possible, I believe, to maintain in extreme low-water a depth of over 1 foot by any system of wing-dams in this river which will leave open a space wide enough for the passage of tow-boats with three barges abreast. A boat and three barges, one ahead and one on each side, make a safe Allegheny River fleet.

Work on the improvement of the Allegheny was undertaken for the first time during the past season, $10,000 having been appropriated for that purpose. With this sum two wing-dams were constructed and the channel was tolerably well cleared of rocks (several thousand having been removed) for 30 miles above Pittsburgh. To extend the work already begun up to Warren would cost as follows:

First division.—Pittsburgh to Brady's Bend, 69 *miles.*—The improvement to Brady's Bend would enable oil boats to load with oil from the Butler or lower oil regions and would be of the first importance to the limestone trade. It would also enable rafts from the Kiskiminetas, the Red Bank, and the Mahoning rivers to descend with safety at the lowest stage in which they can float. For this division I would estimate as follows:

To finish the two dams built in 1879	$4,000
12 dams, costing $3,500 each	42,000
For the removal of rocks, &c	7,000
Total	53,000

Second division—Brady's Bend to Oil City, 61 *miles.*—This division would extend to the heart of the middle oil fields, and be of benefit to the populous towns of Parker City, Emlenton, Franklin, and Oil City. It would also develop a large coal trade, and enlarge the stave and lumber business from the Clarion River, French Creek, &c. This division would require—

10 dams, costing $2,500 each	$25,000
Removal of rocks, &c	3,000
Total	28,000

Third division—Oil City to Warren, 58 *miles.*—The improvement of this division would be of great benefit to the lumbermen, and an advantage to the thriving towns of Tionesta, Tidioute, and Warren. It would no doubt be the means of developing an extensive trade in hemlock bark.

For this division I would estimate as follows:

19 wing-dams, at $1,500	$28,500
For the removal of rocks, &c	2,000
Total	30,500

The total for the improvement of 188 miles of river, allowing 10 per cent. for engineering and contingencies, and including $10,000 already expended, amounts to $133,650, which makes an average of less than $700 per mile.

GENERAL DESCRIPTION OF THE ALLEGHENY RIVER BETWEEN OLEAN, NEW YORK, AND FRANKLIN, PENNSYLVANIA., 132 MILES.

The survey was begun at the mouth of Olean Creek, August 22, 1879. Olean Creek enters the Allegheny River from the right at the town of Olean, Cattaraugus County

New York. Below the junction of the streams there is a detached bar on the right, from the head of which to the upper end of Hoop's Island, 500 feet, the channel is narrow and crooked, but has a depth of 1.1 feet in low-water. The channel passes down to the right of Hoop's Island. There is no trouble at this point, the ripple being scarcely appreciable. About 1,500 feet below the starting-point, the Allegheny is crossed by an open highway bridge. It is a through iron truss 240 feet long, divided into 3 spans of 80 feet each, elevated in the clear 16.5 feet above low-water surface. The rafting channel is under the middle span. The high-water of 1873 rose 15.8 feet above low-water mark, or to within a few inches of the bottom chords of this bridge. Thence the channel continues in mid-river, with a depth of over 2 feet, to Parker's Dam.

Parker's Dam, 1.11 *miles below Olean*.—This is the remnant of an old mill-dam. On the left, a portion of the crib-work remains standing 2 feet above low-water. The channel past this obstruction is 150 feet wide and 2¼ feet deep in low-water. The descent in a distance of 300 feet is 1.42 feet. For the present no work seems to be necessary at this point.

Warren and Bradford Narrow-Gauge Railroad Bridge, 1.33 *miles below Olean*.—This is a wooden Howe truss through bridge. The abutments and piers are timber resting on piles driven into the soft gravel, which for many miles below Olean forms the bed of the Allegheny. This bridge has 3 spans of 100 feet in length each; height in clear above low-water, 20 feet. The channel-way passes under the central span. Thence the river is clear of obstructions and easy to navigate to Allegheny Station.

Allegheny Station, 4.43 *miles below Olean*.—This is a station on the Erie Railroad, on the right bank of the river. The river is here crossed by a highway bridge of four spans, each 100 feet in length. One of the shore spans is built of wood, but the other three are iron bow-string girders. The bridge is 19.4 feet in the clear above the low-water surface. The channel under either of the central spans is taken by the raftsmen. Thence, after passing three ripples, with a least depth of 7 inches and scarcely appreciable fall (see tables of ripples), the channel remains good to Vandalia Station.

Vandalia Station, on the right bank, 10.4 *miles below Olean*.—The station is about half a mile distant from the river, across a low, flat bottom. A bridge crosses the river at this point. It is a cheap wooden highway bridge of Queen trusses, with three spans as follows: right shore span 60 feet, middle 150 feet, left shore 80 feet. The middle span has fallen down, and as the channel passes through this opening the bridge, so far as height is concerned, is no obstruction. As originally built, its height in the clear was 15.2 feet above low-water surface. The missing span was doubtless carried out by a flood. The channel remains good to an island 0.8 mile below the bridge.

Island, 11.1 *miles below Olean*.—This is the first island below Olean. It is 600 feet long, but as it is entirely covered at a 4-foot stage it scarcely deserves the name. The channel passes down the right-hand chute and has a depth of 1.8 feet. Length of ripple, 1,300 feet; fall, 2.06 feet. This is the first considerable ripple. The bottom throughout is fine gravel, no rocks, either solid or detached, having yet been noticed in the river bed. The channel thence remains good, with no important ripples, to the bridge of the Bradford Branch of the Erie Railroad.

Bradford Branch Railroad Bridge, 14.7 *miles below Olean*.—This is an uncovered through bridge of wooden Howe trusses, and it crosses the river with one span of 185 feet. The abutments have been extended 50 feet out into the river on each side, narrowing the natural width 100 feet. As its lower chords are only 14.4 feet above low-water surface, the bridge will probably be carried away by the first high freshet. It has been built since the sudden development of petroleum in the Bradford oil region, and it is questionable whether it will last as long as the excitement in that district.

Tuna Creek, 15 *miles below Olean*.—This is a considerable tributary entering from the south or left hand. It heads in McKean County, Pennsylvania, and passes through the Bradford oil country. A large number of rafts come down this stream in high-water from Bradford, which is 12 miles up. Immediately below its mouth the Allegheny is crossed by a bridge.

Tuna Creek Bridge, 15.1 *miles below Olean*.—This is an uncovered highway bridge of wooden Queen trusses, with a total length of 320 feet. It has two channel-spans, each of 104 feet, and two shore-spans, the right one being 72 feet and the left one 40 feet. The elevation in the clear above the low-water surface is 26 feet.

Bridge 18 *miles below Olean*.—A ponton bridge crosses the river at the 18th mile. Its length is 230 feet. It is arranged so as to be swung open in the rafting season.

Upper Horseshoe Bend Ripple, 19.5 *miles below Olean*.—This is the first point below Olean at which raftsmen have serious trouble. A small gravel-bar divides the channel. On the right the least depth is 1.8 feet, but the channel is only 60 feet wide. On the left the channel is 150 feet wide, with a depth of 1.2 feet. The fall, in a distance of 850 feet, is 1.62 feet. A wing-dam 150 feet long, closing the right chute, would probably be the means of washing out an easier channel for the raftsmen.

Bemis Boom, 20.7 *miles from Olean*.—This boom is constructed of piles driven at ir-

:ervals of a few feet. It extends from the left shore diagonally across the river. At a point 750 feet below its head the channel is reduced by it to a width of 150 feet. The entire length of the boom is 2,100 feet, terminating opposite the large saw-mill of Mr. J. M. Bemis. Immediately below the saw-mill the river is crossed by a ponton bridge 300 feet long.

Tuna Lumber Company Boom, 21.7 *miles below Olean.*—This boom starts from the right bank and extends diagonally towards the left. At a distance of 600 feet from its head, near the left shore, a channel 100 feet wide is left open. The boom continues along the left shore below the opening a further distance of 3,700 feet. The channel is on the outside of the boom and close to it for some distance, until it leaves the boom to take down the right chute of Lewis Island.

Lewis Island, 22.3 *miles below Olean.*—Great Valley Creek enters from the right 2,000 feet above the head of the island. Some years ago the Tuna Lumber Company closed the right-hand chute of the island (the present channel) with a low dam, the intention being to aid their water-power. The old channel was down the left-hand chute, but this chute was afterwards closed by a mill-dam built entirely across it 2,800 feet below. That side has now become so filled with obstructions that it is no longer navigable. There is a fall of 9 inches at the dam across the right-hand channel. The removal of this dam would benefit the shoals below. The average width of the channel-chute is 250 feet.

Salamanca Bridge, 23.2 *miles below Olean.*—This is a highway bridge that crosses the river 600 feet below the foot of Lewis Island. It stands in shallow water in a ripple, which in a length of 1,200 feet falls 3.32 feet, and has a least depth of 11 inches. It is the most decided fall so far observed on the river below Olean. The bridge is divided into five spans, the three in the center being of iron, and each 85 feet long. The right-shore span is 100 feet and the left-shore span 50 feet long, both through wooden trusses. The entire length of the bridge is 405 feet. It has stone piers resting on piles. The best channel passes under the central span. Height in the clear above low-water surface, 19.2 feet. Salamanca, on the right bank, is a large and thriving town, and is an important railroad center. On the left bank, opposite the lower end of the town, is the Tuna Lumber Company saw and planing mill. It has a daily capacity of 25,000 feet, board measure, of lumber.

Little Valley Creek Island, 24.9 *miles below Olean.*—At the mouth of the creek, which enters from the right below the head of the island, a bar of fine gravel has made out into the river, by which the channel is narrowed to a width of 80 feet, forming a strong ripple with a depth of 1.3 feet. Passing this island, in a distance of 2,400 feet the river falls 3.71 feet. A wing-dam 200 feet long, closing the left chute of the island, would effect a decided improvement to the navigation. About the middle of the island a wagon-bridge of iron bow-string girders crosses the river. Over the right chute it has two spans of 100 feet and one span of 118 feet; over the left chute it has one span of 100 feet. The intermediate section on the island (225 feet long) is supported on piles. Total length of bridge, 643 feet; height in the clear above low-water surface, 20 feet. Immediately below Little Valley Creek Island another island occurs. The channel, in passeng abruptly to the left chute of this island, is reduced to a width between the islands of 200 feet. Very little water passes to the right of the second island at the present low stage. No particular trouble here.

Bucktooth Island, 25.7 *miles below Olean.*—The length of this island (which is cultivated) is 4,000 feet. The channel is to the right, with a general width of 250 feet. Near its foot Bucktooth Run enters the river from the right, and has pushed out a bar, making a shoal ripple, the least depth being 9 inches. There are 3 ripples in the chute of this island, with a total descent of 5.29 feet. From the foot of the island to Jamison's Falls the depth is good.

Jamison's Falls, 27.5 *miles below Olean.*—Length of ripple, 150 feet; fall, 1.81 feet; least depth, 9 inches. Bottom composed of small bowlders.

Jamison's Island, 28.4 *miles below Olean.*—Island 600 feet long and 200 feet wide. Channel down the right. The chute is shoal throughout. In a distance of 200 feet the river falls 2.74 feet, with a least depth of 9 inches. There are some loose rocks in the channel, which could be removed to advantage. A wing-dam 200 feet long, closing the left chute, would add considerable water to the channel. On the right shore there are a number of rocks, varying in size from ½ to 2 cubic yards. These are the first rocks appearing along the river below Olean, and are indicative of a change in the characteristics of the stream. Thence to Sunfish Island the channel remains in mid-river. No trouble.

Sunfish Island, 30 *miles below Olean.*—This island was once cultivated, but has been so much eroded by the river that at present it is a mere gravel bar, covered at a 3½-foot stage. It is 800 feet long and 300 feet wide. The channel is on the left 200 feet wide. A narrow chute, only 50 feet wide, takes around the right. The entire length of the ripple is 1,050 feet, with a fall of 3.03 feet, and a least depth of 1 foot. No improvement appears to be necessary. On the right shore, 600 feet below the island, there is a large crescent-shaped gravel bar, 1,200 feet long and 250 feet wide, covered

at a 1.5-foot stage. The channel passes to the left of the bar, and has a least depth of 11 inches. The ripple is 300 feet long, with a fall of 1 foot, and a channel 250 feet wide. No trouble.

Red House Bridge, 30.98 *miles below Olean*.—This is an uncovered through highway bridge, composed of combination (wood and iron) trusses. The entire length is 410 feet, which is divided into 3 spans of the following lengths, measured from center to center of piers: right hand span, 170 feet; middle span, 132 feet; left channel or shore span, 108 feet. It rests on masonry piers and abutments. The channel passes under the middle span. Height in the clear above low-water surface, 21 feet.

Red House Creek Island, 31.8 *miles below Olean*.—The length of this island is 1,500 feet and the general width is 200 feet. The channel passes down the left chute and is about 250 feet wide, except at a point about midway, where it is narrowed to 150 feet by a bar extending out from the left shore. Ripple at head, 200 feet long; fall, 1.0[illegible] feet; depth, 11 inches. Ripple midway in chute, 550 feet long; fall, 0.95 foot; depth, 11 inches. Considerable water wastes down the right chute. A wing-dam 150 feet long, closing that side, would deepen the channel. The bottom here is composed of fine gravel.

Red House Creek, nearly dry at this season, enters from the left 400 feet below the island. Thence for 2,000 feet the depth is good to Red Honse Island.

Red House Island, 32.5 *miles below Olean*.—The length of this island is 1,600 feet, and its width is 200 feet. It is covered with timber. The channel passes down the left chute. A rapid from near the head of the island extends 600 feet, falling 2.49 feet, with a least depth of 11 inches. The right chute carries a strong stream 50 feet wide even at this low stage, which might be turned into the channel by closing that side with a low dam 400 feet long. From the foot of this island to Robinson's Island, a distance of 4,000 feet, the channel is easy.

Robinson's Island, 33.8 *miles below Olean*.—Length of island, 1,900 feet; greatest width, 225 feet. The channel passes down the left. A gentle ripple, with a depth of 1.5 feet, occurs at the head of the island. It is not troublesome. There is another ripple near the foot of the island, known as "Josh Billings' Ripple." In a length of 400 feet there is a fall of 1.40 feet, with a depth of 2 feet. No improvement seems to be required. From the head of Josh Billings' Ripple a low bar begins to appear on the left of the channel. It is 1,300 feet long and 200 feet wide at its widest part. A little water escapes to the left of it, and the whole is covered by a rise of 6 inches. At the foot of this bar there is a wide-spread shoal and ripple 600 feet long, falling 2.38 feet, with a least depth of 1.5 feet. No special difficulty in the navigation.

Island, 35.9 *miles below Olean*.—Length of this island, 2,400 feet; greatest width, [illegible] feet. The channel is down the right chute. The bar from the head of the island and another from the right shore contract the channel to a width of 125 feet. There is also a short, strong ripple, the river falling 1.02 feet in a distance of 150 feet. Least depth on ripple, 11 inches. Only a trifling quantity of water passes to the left of the island.

Quaker Bridge Island, 36.5 *miles below Olean*.—Length, 1,400 feet; greatest width, [illegible] feet. The deepest channel passes down the right chute. Below the head of the island a ripple occurs measuring 600 feet in length, with a fall of 1.43 feet and a least depth of 11 inches. Above the head of the island the remains of 5 piers, possibly remains of a bridge, obstruct the channel. These should be removed in case a general system of improvements is undertaken on this portion of the river. The island divides the volume of the water about equally, so that the construction of a wing-dam closing either side would undoubtedly improve the depth in the chute left open.

Quaker Bridge, 36.8 *miles below Olean*.—The bridge crosses the river above the foot of the island above mentioned. It is a wooden Queen truss, resting on wooden pile piers. The entire length is 300 feet, divided into 4 spans, averaging 75 feet each. The clear height above low-water is 17.5 feet. One pier stands on the island.

Hotchkiss Island, 37 *miles below Olean*.—This is a cultivated island 4,500 feet long, and with a maximum width of 425 feet. From above its head a small island on the right laps with it a short distance. The channel is between these two islands, and continues down the main or right chute of Hotchkiss Island. There are three ripples in this chute. The first, at the head of the island, is 850 feet long and falls 1.55 feet, with a depth of 1.5 feet. The second ripple, near the middle of the chute, is 1,000 feet long, with a descent of 210 feet, and a least depth of 1 foot. The third ripple is between the foot of the main island and another small island to the right. The low-water width is only 100 feet. The length of this ripple is 200 feet; its fall is 1.41 feet, and its depth is 1 foot. There is no trouble for rafts at this island, but as a considerable volume of water escapes down the left chute of the large island, an improvement could be effected by closing that side with a wing-dam 250 feet long.

Fish Basket Ripple, 38.3 *miles below Olean*.—At this point a low bar 500 feet long, covered at a 2-foot stage, divides the river. The channel is to the right and there is no special difficulty. The length of the ripple is 450 feet, with a fall of 1.24 feet and a least depth of 1.8 feet. About one-half mile below there are two gravel bars in mid-

river with a narrow chute between them. Either shore-channel can be navigated past this obstruction, though neither has a depth of over 10 inches. The entire fall of the river here is 3.37 feet in a distance of 800 feet. Suggestions for improvement are deferred for the present.

Holiday's Island, 39.9 *miles below Olean.*—Length, 2,000 feet; greatest width, 300 feet. The channel is down the left side. At the foot of the island there is a strong ripple, falling 2.84 feet in a distance of 300 feet. Least depth, 10 inches.

Purse Run Bar, 41.3 *miles below Olean.*—This bar is situated in mid-river. It is 900 feet long and 275 feet wide, and is covered at a 2½-foot stage. Nearly all the water now passes to the right, but at one place the water surface is only 80 feet wide; length of ripple, 550 feet; descent, 1.83 feet; least depth, 1.1 feet. No improvement is suggested.

Limestone Falls, 41.6 *miles below Olean.*—The river here falls over a solid ledge of limestone. At this stage the water surface is 200 feet wide. The entire length of the rapid is 650 feet, descending 3.84 feet, with a least depth of 1 foot. Fragments of the ledge, averaging half cubic yard in size, render this place hazardous for rafts during the lower rafting stages. The removal of these rocks would be advisable.

The channel over the falls is near the left shore. At this point on the right, an island 2,900 feet long begins. No water passes behind it excepting at high stages. The island belongs to the heirs of Cornplanter, a celebrated Indian chief of the Six Nations. At the foot of the island (42.2 miles) a low, flat bar, covered at a 2-foot stage, extends out 250 feet into the river from the left and continues for a distance of 1,200 feet. This bar throws the channel close to the foot of the island, whence it continues along the right shore below. Length of ripple at this point, 400 feet; fall, 1.49 feet; depth, 1.2 feet; width of channel, 150 feet.

Zeigler Bar, 42.7 *miles below Olean.*—This bar extends out from the right shore 175 feet and is 900 feet long. Length of ripple, 400 feet; fall, 1.49 feet; least depth, 1 foot. Channel near left shore. No trouble.

Bucktooth Island, No. 2, 43 *miles below Olean.*—Island 700 feet long, 150 feet wide. The best channel passes down the left chute. The water is about equally divided by the island. The least depth found was only 6 inches. A wing-dam 300 feet long, to close the right chute, would be advisable. The ripple is 300 feet long, with a fall of 1.32 feet.

Saw Mill Island, 43.4 *miles below Olean.*—This island is 800 feet long and 175 feet wide. The channel passes to its left, but at one point it is contracted to a width of only 50 feet by a gravel bar from the left. The bar is covered at a 2½-foot stage. The least depth in the channel is 11 inches, but this might be increased by closing the right chute of the island and the left chute of the bar. The ripple falls 2.97 feet in the space of 600. A short distance below this island there is another ripple, falling 1 foot in 300, with a depth of 1 foot. As the water is united and the channel in mid-river, no improvement is suggested.

Little Island, 44.3 *miles below Olean.*—Length of island proper, 400 feet; width, 80 feet. The channel passes close to the left shore and is straight. The right chute of the island is 500 feet wide, but it is obstructed by a high bar, almost an island, between which and the island considerable water wastes in a swift narrow passage.

Immediately below the island an extensive low flat bar pushes out from the right shore to the mid-river line, but does not interfere with the low-water channel. The length of ripple in the channel chute of Little Island is 875 feet, with a fall of 2.22 feet, and a least depth of 1 foot. The bottom is composed of fine gravel. It may eventually prove advisable to close this right chute of the island. A dam 500 feet long will be required.

New York and Pennsylvania State line, 45.1 *miles below Olean.*—At this point there is a shore bar extending out from the left bank to mid-river. There is a gentle ripple abreast of the bar, which has a length of 400 feet, a fall of 0.81 foot, and a depth of 1 foot. It terminates 600 feet north of the line. The State line is the southern terminus of the Seneca Indian Reservation, which extends up 40 miles, with a width on each side of the river of one-half mile. Considerable tracts of this land have been leased to the whites. For the most part the land is a wide, fertile bottom; but the Indians prove to be indifferent farmers, the young men preferring the excitement of rafting to regular labor. These aborigines are remnants of the Senecas and Onandagas, of the Six Nations. But few if any of the pure-blooded original stock can be found among them. They number in all about 500.

Corydon Dam, 46.2 *miles below Olean.*—This artificial work is at present a complete obstruction to navigation, excepting at high stages in the river. Practically the dam is the head of navigation. It is made of timber cribs filled with stone and sheeted with plank. Its length is 280 feet and it entirely closes the river. The fall is 3.54 feet. On the left two mill-races conduct to the saw-mills of Charles & Co. and Morrison & Co., each of which has a daily capacity of 20,000 feet, board measure. On the right, below the dam, is a saw-mill, the property of Mr. J. Dalrymple, with a capacity equal to the others. Immediately below the dam there are two rough stony bars, which are

covered at a 2¼-foot stage, and have a channel between them that is only 75 feet wide. Rafts passing over the dam at moderate stages bend so much as to strike the bottom; many have in this manner been entirely broken up. The ripple between the bars below the dam has a length of 600 feet, with a fall of 2.77 feet, and a least depth of 9 inches.

Ripple, 46.7 miles below Olean.—At this point a bar extends out from the right shore somewhat confining the channel. Length of ripple, 475 feet; descent, 1.24 feet; least depth, 1 foot. No improvement suggested.

Hook's Island, 47 miles below Olean.—Length, 1,400 feet; width, 300 feet. The channel is to the left and easy until the foot of the island is reached, where there is a ripple passing between the head of a second island on the right and a small isolated bar on the left; length of ripple, 300 feet; descent, 2.28 feet; least depth, 11 inches. Formerly there was an island on the left known as Woodbeck's, but the flood of 1865 washed it entirely away, leaving only a low gravel bar 2,500 feet long and 350 feet across at its widest point. It is now covered at a 3-foot stage. No water passes to the right of Hook's Island excepting at freshet stages.

Brown's Island, 47.5 miles below Olean.—This island begins on the left immediately below the foot of Woodbeck's Bar. It is 4,000 feet long. The main body of the river here passes between two islands, the one on the right being 3,000 feet long. A ripple occurs between the islands (at the 47.69 mile), whose length is 300 feet; fall, 1.99 feet; and depth, 1 foot. The bottom of this ripple is composed of bowlders larger than any heretofore observed. At a distance of 900 feet below there is another ripple located opposite the foot of the right-hand island. Here also the bottom is composed of bowlders. Length of ripple, 150 feet; descent, 0.57 foot; depth, 11 inches.

Cornplanter Falls and Island, 48.6 miles below Olean.—Length of this island, 3,400 feet. At its widest part it measures 400 feet, exclusive of its beaches. The channel is to the left, and is of ample breadth excepting at the "falls" or first ripple, situated just below the head of the island. Here a low bar from the left, covered at rafting stages, confines the current to a width of 140 feet. The bottom of the "falls" is composed of a cemented gravel. Length of ripple, 200 feet; descent, 1.97 feet; depth, 1.4 feet. The chute is rather shoal throughout, and has a succession of ripples, which aggregate in length 1,600 feet, with a total fall of 6.23 feet, and a least depth of 1 foot. (See table of ripples for details.) No improvement suggested. At the fiftieth mile from Olean, opposite the mouth of Cornplanter Creek, which enters from the right, a gravel bar divides the channel about equally, and gives a depth of 11 inches on either side, with a scarcely appreciable ripple.

Cornplanter Island No. 2, 50.4 miles below Olean.—This island is about 1¼ miles in length and 700 feet across at the widest point. The channel is to the right. The left chute of the island is closed near its foot with a dam, furnishing power to a saw-mill. The owners at one time attempted to close the right or channel chute by means of a wing dam. A piece of this dam, 100 feet long, projecting into the channel from the head of the island, should be removed. About 2,500 feet below the head of the island an ice gorge in 1865 was the means of cutting the island in two. Through this slough, which is about 100 feet wide, considerable water wastes from the channel. There are 7 ripples in all in the channel chute of this island, aggregating in length 1,850 feet, with a descent of 9.42 feet. The worst one, known as "Gilman's Bar," is just below the cut-off. Here the channel is very much contracted, passing between a central bar and the island. Length of ripple, 500 feet; fall, 3.03 feet; least depth, 11 inches. These shoals would be much improved if the left chute of the island and the slough referred to were closed by means of wing-dams.

Billy's Ripple, 52.3 miles below Olean.—There are here two small detached gravel bars on the left of the channel, and an extensive shore bar on the right. No trouble. Ripple falls 1.80 feet in a distance of 500 feet.

Schoonover Island and Falls, 52.6 miles below Olean.—This island stands in mid-river. Its entire length, including bars, is 1,200 feet, and it is 300 feet wide. There is no special trouble here. The best channel is down the right chute, in which there are two moderate ripples, together measuring 725 feet in length, with a fall of 2.51 feet and a least depth of 1.4 feet.

Harrison's Ripple and mouth of Sugar Creek, 53.3 miles below Olean.—Length of ripple, 400 feet; descent, 1.57 feet; depth, 1 foot. No trouble at this point. There is a large island on the right of the channel, but no water passes behind it, excepting at high stages; 2,200 feet below, Harrison's Lower Ripple is encountered. Here in a distance of 800 feet the river falls 3.12 feet, with a depth of 11 inches. Near its lower end some water escapes to the right of a detached bar. No improvement is suggested at present.

Kinzua Island, 54.5 miles below Olean.—Length of island, 2,200 feet; greatest breadth, 400 feet. No water passes to the left of this island excepting during high-water. The channel passes down the right chute, entering which there is a gentle ripple with a depth of 1 foot. At the foot of the island there is a bar in the middle of the river and the channel passes between it and the island, with a width of 80 feet. The ripple in this passage is 600 feet long, with a descent of 1.28 feet, and a depth of 1 foot. Below

this bar and nearly connected with it there is a small island 600 feet long, the channel passing to its left. From the foot of this island a bar known as "Kinzua Bar," 900 feet long and 190 feet wide, occupies the right half of the river. The entire passage of this island and bar is shallow. The length of the ripple is 1,450 feet; its descent is 1.40 feet, and its depth 1 foot. A few years ago the channel was to the right of the small island and bar, but that side is now nearly closed at this stage.

Ripple, 56.5 *miles below Olean*.—Here two small low detached bars, each 300 feet long, and covered at a stage a few inches higher, divide the volume of the river into three parts. The channel, about 100 feet wide, is down mid-river between the bars. Length of ripple, 375 feet; descent, 1.21 feet; depth, 11 inches. Raftsmen usually float over bars as low as these.

Mouth of Kinzua Creek, 56.6 *miles below Olean*.—This creek enters from the left. It is upward of 30 miles long. At one period its annual output of pine timber amounted to from 10,000,000 to 12,000,000 feet, board measure, but the lumber shipments from its valley are now comparatively insignificant. The town of Kinzua is ¾ of a mile back from the river. The flood of 1865 cut through the neck between the creek and the river at a point 900 feet above the mouth of the former. As there is a crooked, shallow ripple in the river below the cut-off, it would be of advantage to close the gap with a dam 100 feet long in order to utilize the water that wastes through it. The remains of an old mill-dam at the head of this ripple further tends to impede the navigation. Length of ripple, 375 feet; descent, 1.38 feet; depth, 9 inches.

Lower down and nearly opposite the mouth of the creek the channel passes with an abrupt turn between a bar on the right, covered at a 3-foot stage, and the foot of the island on the left. Length of ripple, 200 feet; descent, 1.1 feet; depth, 10 inches. This is followed 400 feet below by a gentle ripple 300 feet long, with a fall of 0.6 foot and a depth of 10 inches. Thence the channel remains fair to Bent's Run.

Bent's Run, 57.8 *miles below Olean*.—This run enters from the left; a bar starting from the right bank, 1,400 feet above the run, extends like a tongue into the river and passes diagonally down stream a total distance of 2,600 feet. From near its head there is a wide "pocket" between it and the right bank; the whole is covered at a two-foot stage. The channel down the left bank is quite narrow below the mouth of Bent's Run, being confined to a space only 75 feet wide; between the foot of the bar and the foot of a small island to the left the depth is 11 inches. No improvement suggested for the present.

Catchall Bar, 58.5 *miles below Olean*.—At this point two low bars in mid-river, covered at a 2-foot stage, confine the channel to a width of 80 feet, close to the left bank. The least depth is 7 inches; length of ripple, 290 feet; descent, 1.90 feet. As some water escapes to the right, it would be advisable to close that side.

Long or Goose Island, 59 *miles below Olean*.—Length of island, 4,800 feet; greatest breadth, 400 feet. A towhead or bar 700 feet long, lying above the island, confines the channel close to the left shore, the water surface being only 75 feet wide. The ripple in this narrow place, in a distance of 160 feet, falls 1.41 feet, with a depth of 18 inches. Continuing down the left, and 1,800 feet below the head of the island proper, a low bar 1,200 feet long, covered at a 1½-foot stage, almost entirely obstructs the channel, as it leaves a passage close to the left bank only 50 feet wide for the entire volume of the river (no water passes down to the right of the island). The least depth in this canal-like passage is 1 foot. There are two ripples, the uppermost one having a fall of 0.73 foot in 60. The other ripple is near the foot of the island and is wider, having a descent of 0.32 foot in 100, and a depth of 1 foot. No improvement is for the present suggested at this island.

Shipman's Island, 60.2 *miles below Olean*.—Length, 1,600 feet; greatest breadth, 200 feet. The point of a bar from the head of the island which lies to the right somewhat confines the channel which passes down the left chute. Here there is a ripple 100 feet long, with a descent of 0.56 foot, and a least depth of 2 feet. The island beach next to the channel is covered with bowlders, whose presence in the river bed or along its banks has thus far been only occasionally observed. No trouble to the navigation.

Buttonwood Island, 60.6 *miles below Olean*.—This island laps the foot of Shipman's Island, and has a length of 2,000 feet. Near its middle it throws out a sharp-pointed bar, which extends beyond the line of mid-river. This causes a gentle ripple, the channel taking to the right of a small detached bar, just showing out of the water and giving a least depth of 1.1 feet. No trouble.

Hook's Islands, 61.6 *miles below Olean*.—There are three islands here, their heads lying nearly abreast of each other. The entire length of the islands is 2,800 feet, the channel taking to the right of them all. A considerable quantity of water is wasted down the various chutes, but when required in the channel one dam 300 feet long will close these leaks. The ripple at the head is 400 feet long, with a descent of 1.27 feet, and a depth of 9 inches. The second ripple, about midway down the chute, descends 1.37 feet in a distance of 250, with a depth of 2 feet. A number of rather large bowlders are visible along the right bank of the river. Below this island a rope ferry, known as "Wardwell's Ferry," is maintained to a small village on the left.

There is a saw-mill in this place operated by water-power, a dam having been constructed for the purpose, which closes the inshore chute of the three islands.

Shipman's Island No. 2, 62.8 miles below Olean.—Island 1,500 feet long and 150 feet wide. The head bar extends up mid-river 900 feet above the island. The channel is to the left. There is a gentle ripple at the head of the chute, with a depth of 1.6 feet. A second light ripple occurs at the foot of the island, with a depth of 9 inches.

Lower Shipman Bars, 64 miles below Olean.—At this point there is a cluster of four small bars to the right, which are covered at a 2-foot stage, and a larger high bar 900 feet long to the left of the channel. There are two moderate ripples here, separated from each other but a short distance. (See tabulated statement.) The least depth is 9 inches. If necessary, the depth could be improved by means of dikes from each shore.

Lower Hook Island, 64.7 miles below Olean.—Length of island proper is 1,500 feet; width, 250 feet. The channel is down the left chute, its entrance being distinguished by a widespread shallow ripple; length, 400 feet; descent, 1.37 feet; depth, 7 inches. No water passes to the right of the island at a low stage; but, fortunately, the channel passage is wide enough to admit of a contraction of the current and still leave room in the middle for a steamboat or barge channel. A gentle ripple opposite the foot of the island has a depth of 1 foot. Glade Run enters from the right, 1,800 feet below the foot of the island. L. A. Robertson's tannery is situated on the left bank of the run, at its mouth.

Mile Island, 65.91 miles below Olean.—Length, 1,200 feet; width, 200 feet, exclusive of bars. The bar above the island extends upstream 500 feet. The rafting channel is usually to the left of this island, on which side the chute is straight; but in low-water the best depth is found down the right. The bar at the head of the island confines the channel close to the right shore. Here there is a ripple 550 feet long, with a descent of 1.85 feet, and a depth of 8 inches. No difficulty, except as regards depth. The question concerning the sides of the island to be closed, in case an increase in the depth is desired, may be deferred for the present. In four-fifths of a mile from the lower end of Mile Island we come to the mouth of Conewango Creek, or "River," as it is sometimes termed. In this distance the Allegheny is generally about 500 feet wide, but quite shallow, and with a rocky bottom. Two unimportant ripples are passed, on which the least depth noted was 10 inches.

Warren Suspension Bridge, Conewango Creek, 67.3 miles below Olean.—This handsome wire bridge crosses the river, with a span of 452 feet, and a height in the clear above low-water of 24.4 feet. Conewango Creek enters from the right, 1,300 feet above the bridge. This is by far the largest tributary the Allegheny has yet received. Its basin is estimated to contain 960 square miles. Lake Chautauqua drains into the Cassadaga, a branch of this stream. The outlet of the lake is 30 miles up the Conewango and Cassadaga. Its surface is elevated about 119 feet above the waters of the Allegheny or 1,294 feet above mean ocean level.

The town of Warren is chiefly located below the mouth of the Conewango and on the right bank of the river; its population is estimated at 4,000. It contains elegant modern county buildings and many fine residences and handsome blocks of business houses, which latter are located chiefly on the river front near the suspension bridge. At one period steamers plied regularly to this point in the spring months from Pittsburgh, 188 miles below. There was, until quite recently, a very extensive trade in pine lumber transacted from this point by river, but as the valley of the Conewango has been almost denuded of this species of timber, its annual value is, in consequence, greatly diminished. Thousands of acres of hemlock still remain, and here, as well as elsewhere, I was assured that if the river were improved an extensive river trade in hemlock bark for tanning purposes would doubtless spring up. Bark is a light, bulky substance, and, from the difficulty experienced in packing it in cars, can only be made remunerative to the railroad companies at rates ruinous to the consumers.

Philadelphia and Erie Railroad Bridge, 67.9 miles below Olean.—This is a covered through bridge of Howe trusses, with three spans of 150 feet from center to center of piers. The height in the clear above low-water surface is 18.6 feet. Eight hundred feet below this bridge a low shore bar from the right, covered at a 3-foot stage, confines the water for a distance of 2,800 feet to the left half of the river bed. At the foot a low bar from the left, making from the shore, covered at a 2-foot stage, further reduces the channel to a width of 150 feet. The current is quite rapid and variable in this passage. Length of ripple, 700 feet; descent, 3.22 feet; depth, 1 foot.

Mead's Island, 70.4 miles below Olean.—Length, 1.1 mile; greatest width, 1,200 feet. The rafting channel is usually down the right. The survey was made down the left chute, in which were found three ripples. The first one, near the head, has a depth of only 7 inches, the river falling 1.45 feet in a distance of 175. The other ripples below have but a trifling descent and a least depth of 1 foot. The right-hand chute of the island not having been specially examined, no suggestions for improvement are offered at present. The only complaint at this point is the lack of depth.

Jackson's Island, 72.4 miles below Olean.—Length, 1,100 feet; width, 200 feet. This

island is situated in mid-river. The left chute is dry at this stage, the channel being down the right. Half way down the chute the river is confined by a bar from the island to a width of 100 feet. The ripple at the head, as soon as you enter the chute, is 770 feet long, with a descent of 1.27 feet, and a depth of 1.9 feet. A gentle ripple at the foot of the island falls 0.85 foot in 200, with a depth of 1.4 feet. No trouble at either ripple.

Grass Flat Island and Bar, 73 *miles below Olean*.—Length of island proper, 1,000 feet; width, 150 feet. The island is preceded by a towhead 900 feet long. The channel passes to the right of the towhead and island, but the chute is shoal throughout, with a number of small detached bars showing out of water in various positions.

The entire chute may properly be considered as one ripple. Length, 1,865 feet; descent, 3.85 feet; least depth, 7 inches. On account of the bars and the scanty depth, it would be advisable to concentrate all the water in the right chute by closing the left one. Thence passing one unimportant ripple at the 73.67-mile point, depth 9 inches (the river passing to the right of a detached bar), we come to a cluster of small bars covered at 2 feet depth (73.82 miles). Here the best depth was found close in to the right shore in a very contracted passage, not over 50 feet wide, with a depth of only 8 inches. The fall in 120 feet is 1.88 feet. It is possible a dam from the left bank carried to mid-river, and thence turned down a few hundred feet, would effectually sweep out these bars and afford a better depth.

Fish-Dam Ripple, 74.62 *miles below Olean*.—A number of scattered rocks show themselves in mid-river, as we approach this ripple. In addition, a bar from the right shore contracts the river somewhat at the ripple. The latter is 300 feet long, falling 1.41 feet, with a depth of 2.4 feet. No improvement required excepting the removal of the rocks.

Brokenstraw Creek, 75 *miles below Olean*.—The town of Irvineton, the junction of several railroads, is situated on the right bank of this creek ½ mile above its mouth. The Brokenstraw is an important feeder of the Allegheny. It was once a great lumbering stream. Its drainage area is about 540 square miles. Like French Creek and the Conewango, this stream heads in the high plateau bordering Lake Erie. These three streams are remarkable for the persistency of their discharge in seasons of drought. I know of no creeks in the Ohio Valley so remarkable in this respect. Possibly the cool, elevated regions in which they originate may be more abundantly supplied with perennial springs than any area of equal extent below. The cooler temperature may also be the cause of less rapid evaporation in the autumnal months.

Brokenstraw Island, 75.7 *miles below Olean*.—Length, 1 mile; greatest width, 600 feet. The channel is to the right of this island, and is impeded by four ripples. The one at the head is the only one with a descent worth noting, namely, 2.42 feet in 525. It has a depth of 9 inches. The others have about the same depth. (See table for details.) Should it prove necessary to increase the depth here, a wing-dam 400 feet long would close the left chute of the island. Considerable water wastes down that side, and either channel can be taken at rafting stages.

Dunn's Island, 77.7 *miles below Olean*.—Length of island, 1.27 miles; greatest breadth, 900 feet. The channel is to the right. The ripple at the head of this island falls 2.28 feet in a distance of 1,020, with a depth of 1.9 feet. No trouble. From below the middle of this island a long, shallow ripple extends to the foot of it. Least depth opposite the foot of the island, 7 inches. Length of ripple, 2,900 feet; descent, 5.06 feet. A wing-dam closing the left chute of this island, 300 feet long, would be a desirable improvement.

Clark's Island, 79 *miles below Olean*.—Length, 3,900 feet; greatest breadth, 400 feet. The channel is to the right. Seven hundred feet down the chute there is a cluster of six low bars composed of fine gravel, covered at a 1½-foot stage. These bars confine the channel close to the right shore for 1,000 feet. No special difficulty in passing them. Length of ripple at this point, 850 feet; fall, 1.79 feet; least depth, 1 foot. Thence to the foot of the island the channel is wide and easy, the depth varying from 2 to 3 feet.

Thompson's Island, 80.6 *miles below Olean*.—Length, 2,200 feet; width, 400 feet. From the head of the island a bar extends up-steam 1,000 feet. The channel is down the right of the island, but for some distance it is confined by the head bar to a width of 100 feet, passing close to the right bank. In this chute there is a ripple 850 feet long, with a descent of 1.79 feet, and a depth of 2 feet. Near the foot of the island another ripple occurs 1,150 feet long, falling 1.91 feet, with a least depth of 10 inches; thence there is from 3 to 5 feet of water through Thompson's Eddy to Farley's Island.

Farley's Island, Conklin's Run, 82.6 *miles below Olean*.—There are two islands here, with a total length of 5,000 feet. The head of the second island commences a few hundred feet below the foot of the uppermost (outside) islands. The channel is to the right of both islands. The ripple on the channel side begins above the head of the first island and extends down 2,100 feet. Least depth, 1.2 feet; descent, 3.10 feet. Near the foot of the second island another but gentle ripple occurs. The channel, curving towards the island, has a depth of 2 feet while passing a small detached bar on the right, which just shows out of water. No improvement seems necessary.

Smith's Bar, 83.9 *miles below Olean*.—The uppermost bar is 1,500 feet long and 350 feet wide. It obstructs the entire right half of the river bed, being separated from the shore by a chute only 50 feet wide, through which, however, considerable water escapes. The channel passes to its left. At the foot of the bar there is a widespread shoal on which there is only 6 inches of water. The river in a manner falls over a reef at this point, having a descent of 1.07 feet in 50. Suggestions for improvement should be deferred until a more careful examination can be made.

Millstone Island and Bar, 84.8 *miles below Olean*.—The low-water channel here passes between an island on the right (4,900 feet long, including 800 feet of head bar) and a high bar, 2,100 feet long, on the left. For 800 feet below the head or entrance there is a sharp rapid in the channel, which is only 50 feet wide. The water descends 2.39 feet in 800, with a depth of 1 foot. Thence a gentle ripple continues a distance of 2,000 feet to the foot of the bar, having a fall of 1.30 feet and a depth of 1 foot. About one-half the volume of water takes the channel chute, the remaining half being about equally divided between the other two chutes. Dams from each shore may be necessary in the future.

Magee's Island, 85.9 *miles below Olean*.—The island proper is 2,400 feet long and 200 feet wide. The channel is wide and easy down the left of this island until we arrive opposite its foot, where there is a ripple 800 feet long and 1 foot deep, with a descent of 1.84 feet. From this point a tail-bar from the island, known as Goose Neck Bar, 2,000 feet long, confines the channel close to the left bank, where for some distance it is only 100 feet wide. In this chute there is a ripple 500 feet long, having a descent of 1.81 feet and a least depth of 1 foot.

Coursin Island, 87.8 *miles below Olean*.—Length of island, 4,400 feet; greatest width, 500 feet. The channel is down the left shore. At the entrance to the chute there is a gentle ripple 750 feet long, with a depth of 1.9 feet. Lower down another ripple is found, 1,200 feet long, with a fall of 2.88 feet and a depth of 1.8 feet. There are a number of snags lodged in the river bed below the foot of the island. No trouble at this island excepting from these snags.

Tidioute Suspension Bridge, 89.7 *miles below Olean*.—This is a wire suspension bridge, with two spans of 268 feet each, elevated in the clear above low-water surface 27.5 feet. The channel is under the left span. The town of Tidioute is on the right bank. The population is estimated at 2,000. Oil-pipe lines extend from Titusville to this point, where the oil is delivered on the cars of the Pittsburgh, Titusville and Buffalo Railroad. Railway tracks are continuous on the right bank of the river from Warren to Oil City and Franklin. (Railroads follow either one or the other, sometimes both, banks of the Allegheny River all the way from Olean to Pittsburgh, 255 miles, except from Red House to Warren, a distance of 36¼ miles.)

Tidioute Island, 89.8 *miles below Olean*.—Length, 1,300 feet; width, 200 feet. Below the bridge there are a number of small stony bars. The channel is to the right of the island, but is crooked and much obstructed, both at the head and at the foot, with gravel lumps and rocks. It is a place calling for scraping or dredging in addition to what might be done with low dams to concentrate the water. The ripple at the head is 375 feet long, with a descent of 1.73 feet and a depth of 7 inches. The ripple at the foot is 400 feet long, with a descent of 2.11 feet and a depth of 1 foot.

Irvine Island, 91.2 *miles below Olean*.—Length, 1,400 feet; width, 300 feet. The channel is to the right and is wide and easy. A gentle ripple at the head as you enter the chute has a depth of 1.7 feet. Below the head of the island two large detached flat bars in mid-river (covered at a 4½-foot stage) confine the channel close in to the right bank. These bars extend down for 1,400 feet. Length of ripple, 1,000 feet; descent, 2.31 feet; least depth, 1 foot.

Porterfield Island, 92 *miles below Olean*.—From the head of this island for 2¼ miles the channel follows the right bank, having on the left a continuous series of islands and bars, numbering fifteen in all, which do not need special mention. This portion of the river may be described as a series of ripples and shoals, with a channel which is occasionally very tortuous. In 8,350 feet from the head of Porterfield Island there is a fall of 5.77 feet, with a least depth of 1 foot.

At various points there are rocks or large bowlders projecting above the surface, which could be removed to advantage. At the ninety-fourth mile a bar causes an unusual contraction of the channel. At this point a ripple 500 feet in length has a descent of 1.58 feet and a depth of 6 inches. This is the shoalest place in the series. The river, in this bad stretch, admits of improvement by the removal of rocks and the closing of several of the chutes with dams.

White Oak Island, 94.3 *miles below Olean*.—Length of island, 3,400 feet; width, 500 feet. The channel here turns from the right shore at an angle of about 45° and crosses to the left. It passes close to the head of the island and between it and a detached bar to the left. This place is known as "White Oak Chute." This fall is 2.38 feet in distance of 450 feet, and the depth is 6 inches. The bar to the left and the river bed are composed of fine gravel. A dam 300 feet long, closing the right chute of the island, would be advisable.

The residue of the channel down the left of the island is wide and abundantly deep, varying from 2 to 6 feet.

Hemlock Island, 96 miles below Olean.—Three thousand five hundred feet long, 500 feet wide. The channel is down the left chute. The ripple at the head has a length of 945 feet and a descent of 2.90 feet, with a depth of 1.3 feet, and a gravel bottom. No particular trouble. At the foot of the island there is a ford in a ripple 350 feet long, with a descent of 1.13 feet and a depth of 1.6 feet. The village of East Hickory is situated on the left bank. Below the island for some distance the channel is in mid-river, confined between several bars on the left (known as Fishing Bars) and an island on the right, but there is no special difficulty in the navigation. Fishing Bar Ripple has a descent of 1.82 feet in 300, with a depth of 1 foot.

East Hickory Creek, 97.6 miles below Olean.—This creek enters from the left. The channel here deflects suddenly to the right bank in a ripple whose length is 500 feet; descent, 1.22 feet; and depth, 6 inches. The river in the ripple is united in one body, but it is possible that the depth might be increased by scraping so as to reduce the width of channel. Thence the channel follows the right shore a short distance to Dorkaway or West Hickory Bar.

West Hickory Bar, 98.3 miles below Olean.—At this place low bars from each shore gradually converge until the channel flows between them in a space only 150 feet wide. The ripple is not at all troublesome, its length being 650 feet, descent 1.93 feet, and depth 1.5 feet. The town of West Hickory, located on the right bank, is about one-half mile below this ripple.

Hickory Town Island, 99.5 miles below Olean.—Length, 1,500 feet; greatest width, 400 feet. The channel is down the left and is comparatively easy. The ripple at the head is 310 feet long, with a descent of 0.95 foot, and depth of 1 foot. The ripple at the foot is 800 feet long, with a descent of 1.81 feet, and a depth of 1 foot. A bar from the foot of the island, covered at a 4-foot stage, tails down in mid-river for 2,000 feet.

Dawson's Ripple, 100.6 miles below Olean.—At this point the channel crosses from the left to the right bank, leaving a shore bar on the left. The ripple has a width of over 300 feet, with a descent of 1.06 feet in 220, and a depth of 10 inches. Not troublesome, if we except the lack of depth.

Dale's Islands, 101.5 miles below Olean.—Two islands in line in mid-river; the lower is separated from the upper bar by a distance of only 100 feet, which space is occupied by a dry bar. The united length of the islands is 4,800 feet, and the greatest width is 600 feet, measured across the lower island. The channel passes to the left of these islands. Three hundred feet down the chute a low bar 500 feet long, covered at a 1½-foot stage, confines the channel to the left bank in a passage only 80 feet wide. The ripple measures 530 feet in length with a descent of 2.35 feet, and a depth of 11 inches. Some water escapes along the channel to the right of the bar. Soft gravel bars like this are easily moved by the action of ice gorges. Two other ripples occur in the chute below, but they are marked by no special difficulty except that at the first one there is a rock containing 25 cubic yards in mid-river, projecting 5 feet above low-water surface. This rock is much worn by the action of ice. Raftsmen take the right chute of this island, which side should be more specially examined before concluding on any plan for improvement. Below this the channel passes to the left of a chain of three small islands known as Middletown islands, with no special trouble to Tub's Run Bar.

Tub's Run Bars, 103.2 miles below Olean.—The channel is here somewhat confined between a left-hand shore bar and a bar in mid-river. Length of ripple, 500 feet; descent, 2.41 feet; depth, 7 inches. This place can be improved by confining all the water in one body by the construction of several short wing-dams closing the various outlets.

Hunter's Island, 103.4 miles below Olean.—Length, 900 feet; width, 200 feet. The channel passes down the left. A bar 1,700 feet long extends down below the foot of the island. Near the foot of the bar there is a ripple 700 feet long, with a descent of 1.77 feet, and a depth of 10 inches. No particular difficulty here. Good water thence to Tionesta Bridge.

Tionesta Bridge, 104.4 miles below Olean.—This is an iron bridge of bow-string girders, with three spans of 120 feet each, and a left-shore span 75 feet long. The total length of the bridge is 435 feet. It rests on stone piers and abutments. The clear height of the bridge above low-water is 25¼ feet. The channel way is under either of the central spans, and the depth is 4 feet. The town of Tionesta, the county seat of Forest County, Pennsylvania, with a population of 500, is located on the left bank, just above the mouth of Tionesta Creek. Tionesta Creek enters from the left, or east, and it drains about 220 square miles. It is still an important lumbering stream, the quantity annually delivered at its mouth being 20,000,000 feet board measure of lumber, 200,000 bundles of shingles, and 160,000 bundles of laths. The value of this product is over $400,000.

Tionesta group of islands, 105 miles below Olean.—There are here eight islands, all to the left of the channel, which follows the right bank past them for nearly 3 miles.

Five of these Islands form a chain in mid-river, the three remaining ones forming a short parallel chain inside of the others. The largest island is 2,100 feet long and 500 feet wide. There is no special difficulty in the channel past these islands. The ripples are gentle, and only at one point was the depth as little as 1 foot.

Tionesta Creek enters the river behind the head of this group of islands. Raftsmen experience much difficulty in getting out of the Tionesta into the Allegheny. The natural difficulty was aggravated by the construction of a dam in the mouth of the creek, which, instead of proving an aid, has increased the trouble. It would cost but little to change the position of that dam and open a chute into the river above the head of all the islands.

Cushion Bars, 106.9 *miles below Olean.*—Just above these bars the channel turns abruptly from the right bank to the left. Following that side a few hundred feet, a cluster of very small bars, covered when the river rises a few inches, confines it close to the left bank with a width of 100 feet. The ripple through this place is 1,175 feet long, with a descent of 1.85 feet and a depth of 1 foot. Thirteen hundred feet farther down the water is confined to the right shore by a similar set of bars, but with a wider channel-way. The ripple is 400 feet long, with a descent of 0.96 foot, and a depth of 1.7 feet.

Holman's Island, 108.3 *miles below Olean.*—Length, 4,200 feet; greatest width, 600 feet. The channel is down the left of this island, and is comparatively easy. Midway down the chute there is a ripple 350 feet long, with a descent of 1.33 feet, and a depth of 11 inches. At the foot the channel makes nearly a square crossing to the left bank, in order to avoid a small island which interlaps Holman's Island. The depth in this crossing is about 1 foot. No trouble. Thence the channel holds along the left shore to Maple Island.

Maple Island, 109.4 *miles below Olean.*—Length, 1,700 feet; width, 280 feet. The channel is down the left chute; midway in this chute a small island to the left confines the channel between the two. Here the river is much obstructed by gravel lumps. Two ripples farther below make nearly one continuous ripple, their united length being 1,1[illegible] feet; descent, 2.93 feet; and least depth, 10 inches. A dam closing the right chute of Maple Island would probably be the means of washing out a better channel and improving the depth.

Rapids, 110.5 *miles below Olean.*—Above this point a bar from the left throws the water across to the right, giving a passageway only 100 feet wide. There is here a sharp rapid, the water in 130 feet falling 2.09 feet, with a depth of 1.4 feet. The only trouble comes from the swiftness of the current.

Hemlock Creek Island, 111.9 *miles below Olean.*—The length of the island proper is 9[illegible] feet, and its width is about 200 feet. There is a small island of the same name well inshore, opposite the mouth of Hemlock Creek (which enters from the left). On the left bank, and above the creek, an enterprising citizen has erected an extensive hotel called the President House. It is noticeable chiefly because there are no other buildings near it. The channel passes down the right chute of Hemlock Creek Island. For some distance it is quite narrow, being driven close to the main shore by the head of the island. Length of ripple, 1,140 feet; descent, 3.4 feet; depth, 1 foot. The bottom is composed of loose rocks, some of which could be removed to advantage. A few of these rocks project more than a foot above the surface of low-water.

McCrary's Bar, 112.8 *miles below Olean.*—This bar, now covered at a 4-foot stage, was formerly an island. It is 1,500 feet long and 250 feet wide. The channel passes on either side, there being no material difference in the depth. There is a gentle ripple entering the right chute with a depth of 1.8 feet. Six hundred feet below McCrary's Bar, another bar, in mid-river, 900 feet long, and covered at a 1½-foot stage, confines the channel to the left. At its foot a bowlder reef extends entirely across the river. The depth on this was only 4 inches. The river falls at this place 1.48 feet in a distance of 70, which is certainly a remarkable jump.

Plans for improvement are deferred for the present. Thirteen hundred feet below opposite the mouth of Henry Run (which enters from the right), there is a gentle ripple with a depth of 1.1 feet; it gives no trouble.

Pit-Hole Islands, 115.3 *miles below Olean.*—These are two small islands. The channel passing to the right of the upper one is wide and shallow, and full of loose bowlders. Pit-Hole Creek, a considerably tributary, enters from the right, opposite the foot of the first island. Its mouth is 100 feet wide. Two railroad bridges (one railroad extending up the valley of Pit-Hole Creek) cross it.

From the mouth of the creek the best channel (still in the right-hand chute) passes close over to the second island, hugging it to its foot, leaving a number of small, dry bars to the right, and others extending some distance below.

This is an exceedingly swift place, the river falling 4.65 feet in 1,300, or at the rate of about 18 feet per mile. The depth found was not quite 1 foot. Scarcely a vestige remains of Pit-Hole, which was once a center of the oil excitement. At one time its post-office was the second in importance in Pennsylvania.

Walnut Island, 116.8 *miles below Olean.*—The first island is 1,700 feet long and 500 feet

vide. A head bar extends above it a distance of 1,300 feet. The channel is to the right. In entering, passing between the bar and the right bank, the channel is only 00 feet wide and 10 inches deep. The ripple in this place descends 2.61 feet in a distance of 1,360.

The second island is 1,000 feet long, and it commences immediately below the first. The channel is on the right, and it has several small detached bars on each side. The ripple at the lower end is 910 feet in length, with a descent of 1.92 feet and a depth of foot. A wide-spread ripple occurs in the river about one-half mile farther down. Its length is 1,390 feet, and its descent is 2.90 feet, but as the least depth observed was 2 feet, no improvement seems necessary. Four more ripples occur at intervals in the river to Alcorn's Bar, a farther distance of about 4 miles, but they give a navigable depth greater than 1 foot. In this reach a number of small islands and bars occur, but the channel holds to the right of them all.

Alcorn's Bar, 122.4 *miles below Olean*.—This is a long bar in mid-river, just below a little island called Horse Creek Island. The bar is 3,000 feet long and is 250 feet wide, and is covered at a stage of 3½ feet. The channel is on the right of the bar, where there is a ripple 2,100 feet long, with a descent of 1.37 feet, and a least depth of 1.2 feet. At the extreme lower end of the bar another ripple is found 500 feet long, with a descent of 1.99 feet, and a depth of 1.9 feet. There is no special difficulty at either of these ripples. The Imperial Oil Refining Company, one of the Standard Oil Company's works, is located on the right bank. It is the first oil-refining establishment met with below Olean, and is said to be the most extensive in the United States. It certainly pollutes the river with enough refuse to justify the encomiums that are passed on its capacity.

Allegheny Valley Railroad Bridge, 124.4 *miles below Olean*.—This bridge crosses the river diagonally. It is a covered wooden structure on the Howe truss principle, with three spans, each 150 feet long, elevated in the clear 29 feet above low-water. The channel is under either the left or the central span. Oil City, on the right bank, begins at this bridge, and South Oil City is found on the left bank. These two places together have a population of about 8,000. The highest recorded flood in the Allegheny at this point occurred in March, 1865. Our levels up to the mark show that the river rose on that occasion 17½ feet above the low-water mark. This is only 1 foot higher than the river is reported to have risen at Olean in 1873. The channel between the railroad bridge and the Oil City bridge is nearest to the left bank, leaving a low bar, once an island, on the right.

Oil City Bridge, 124.8 *miles below Olean*.—This bridge crosses the lower end of the bar referred to, its right shore abutment being about 200 feet above the mouth of Oil Creek, a large tributary of the Allegheny (on this stream are the towns of Petroleum Centre and Titusville). The length of the bridge is 1,100 feet, divided into 6 spans, the longest of which measures 200 feet. The height in the clear above low-water is 20 feet. About 900 feet below, the river is crossed by a suspension bridge divided in three spans, the longest measuring 500 feet. The total length of the bridge is 700 feet, and it is elevated in the clear 41 feet above low-water. A rocky ripple occurs between the railroad and the suspension bridges, measuring 1,100 feet in length, with a total descent of 3.25 feet, and a least depth of 1.3 feet. Two-thirds of a mile below the suspension bridge a large bar, which is covered at a 4-foot stage, makes off from the left shore, and throws the channel to the right. It is not a troublesome place. Length of ripple, 275 feet; descent, 1.16 feet; depth, 2 feet.

Holliday's Bar, 126.9 *miles below Olean*.—Here an extensive bar 2,200 feet long, covered at a 4-foot stage, again confines the river to the right shore. The ripple is 900 feet long with a descent of 3.56 feet, and a depth of 1.4 feet. No particular difficulty at this point.

Schaeffer's Bar, 128.3 *miles below Olean*.—At this point a large bar on the right, covered at a 4-foot stage, confines the river to a width of 150 feet close to the left bank. Through this chute for 1,900 feet the current is strong, the descent being 3.25 feet, with a least depth of 1 foot. At its lower end there are a number of rocks in the channel. The river is shoal for ½ mile below this ripple, with a least depth of 18 inches, and a considerable current.

Two-mile Run Bar, 130 *miles below Olean*.—At this point a flat bar, 1,100 feet long and 200 feet wide, covered at a 1½-foot stage, confines the channel to the left. The depth on the ripple is 7 inches; length, 450 feet; descent, 2 feet. Much water is lost to the right of this bar, which might be utilized to advantage by closing that side with a wing-dam 400 feet long.

McDowell's Islands, 131.4 *miles below Olean*.—These two once made a continuous island, but at some time prior to 1853 they were cut through near the lower end. Their united length is 3,000 feet, but with head bar and connecting bar they measure 4,800 feet. The channel is down the left, which is shoal throughout the entire chute. In 4,800 feet the river descends 4.20 feet. The least depth in the channel is 1 foot, but it is generally about 2 feet deep.

French Creek, Franklin, 132 *miles below Olean*.—French Creek enters from the right immediately below the foot of McDowell's lower island. The survey was closed at

this point October 21, 1879. French Creek is the largest tributary of the Allegheny. It heads in New York, and drains about 1,050 square miles. Conneaut Lake, on one of its branches, was the source from which a portion of the water supply for the Pennsylvania Erie Canal was drawn. It is a noteworthy fact that a dam raising this lake only a few feet enabled its waters to flow into a canal which discharged into Lake Erie. Franklin, immediately below the mouth of French Creek, has a population of 6,540.

* * * * * * *

SYNOPSIS.

The 190 ripples average 617 feet in length and 1.6 feet in descent. Their aggregate descent is 304.77 feet, which, deducted from the total descent of the river between Olean and Franklin, leaves 141.49 feet, or an average descent of 1.07 feet per mile for the residue of the river. In length the shoals are 17 per cent. of the entire distance.

From the mouth of French Creek to Pittsburgh, 123 miles, there are seventy-five ripples, the total descent of the river in that distance being 261.7 feet.

It is proper for me to add that for much of the substance of the detailed description of the river above Franklin I am indebted to Mr. John B. Dougherty, assistant engineer, who conducted the survey in the field. Being called to the East on other work, he was unable to make any regular report himself, but left his notes and field books with me.

I will note here that the adopted elevation of Olean was taken from the late geological report of Pennsylvania, one volume of which is devoted to tables of elevations of various railroad points within the State and on its borders. Since this table was prepared I have received the elevations adopted by the canal surveys of New York, from which it appears that our elevation at Olean is 14 feet lower than theirs.

Respectfully submitted.

THOMAS B. ROBERTS,
Assistant Engineer.

Col. WM. E. MERRILL,
Major, Corps of Engineers, U. S. A.

X 4.

HARBOR OF REFUGE NEAR CINCINNATI, OHIO.

At the close of the fiscal year ending June 30, 1879, the contract for constructing two dikes at Four-Mile Bar, 10 miles above the public landing of Cincinnati, had just been awarded to Mr. John J. Shipman, of Lewinsville, Va.

During the last fiscal year the dike on the Ohio side of the river was extended to its full length of 2,135 feet; but the outer end was not wholly finished, as the work was stopped by high water. At the close of the fiscal year the condition of the work was as follows:

The Ohio dike was completed to its full length, except that the stone filling had not been smoothed off, and that from one to two courses on top of the outer portion of the back wall, together with the corresponding back braces had not been laid. For a distance of 516 feet measured from the bank, the dike had been wholly finished. This latter is the most important part of the work, as it crosses the Ohio chute, the former channel in dead low-water. A small amount of the bank protection was also unfinished.

The effect of this dike upon the low-water channel abreast of it has been excellent. In many places the sand and gravel carried in suspension by the river have deposited behind the dike up to the level of the back wall, and the interstices between the stones inside the cribs are almost wholly filled. Everything gives promise of a strong and durable work.

As there was no ice last winter, there was no test of the efficiency of the dike for holding back ice-floes.

The *Kentucky dike* had been located, and work had been commenced on the bank protection at its root when the fiscal year ended.

The amount of the original appropriation will complete these dikes to the full length required for their use as ice-holders. The Kentucky dike should be extended to a greater length than is necessary for this purpose in order to increase its efficiency as a low-water improvement. This latter use is, however, foreign to the purpose for which this special appropriation was made, and on this account authority has been granted to make the extension at the expense of the general appropriation for improving the Ohio River.

I therefore submit no estimate for any further appropriation for the harbor of refuge.

It may be proper to add that, owing to the great length of the Four Mile Bar, another dike will probably be needed to complete the low-water improvement; but it is not advisable to plan this dike until the present dikes have had an opportunity to develop their full effects upon the bar.

Money statement.

July 1, 1879, amount available		$49,878 07
July 1, 1880, amount expended during fiscal year	$28,401 46	
July 1, 1880, outstanding liabilities	173 18	
		28,574 64
July 1, 1880, amount available		21,303 43

X 5.

ICE HARBOR AT MOUTH OF MUSKINGUM RIVER, OHIO.

The river and harbor act approved March 3, 1879, contained an appropriation of $30,000 for an ice harbor at the mouth of the Muskingum River, Ohio.

Various legal difficulties intervened to prevent early action under this appropriation, and it was not until the 17th of November that I was finally notified that the funds were available.

As the amount appropriated was less than one-seventh of the estimated cost of the work, it was evidently unadvisable to commence construction. It was therefore decided to advertise for the delivery of stone for the lock.

Bids were opened on the 23d of January, 1880, with the following result:

No.	Bidders.	Dimension stone, per cubic yard.					Rubble, per cubic yard.	Aggregate of bid.
		16 to 18 inches high.	19 to 21 inches high.	22 to 24 inches high.	25 to 30 inches high.	Average price.		
1	Thomas B. Townsend	$3 00	$3 00	$3 00	$3 00	$3 00	$2 16 3/16	$32,736 00
2	John J. Shipman	2 97	3 24	3 50	4 05	3 44	2 25	35,650 00
3	Jackson, Butin & Clough	3 15	3 25	3 30	3 35	3 26¼	2 40	35,992 50
4	M. J. O'Connor	3 75	3 90	4 00	4 10	3 93¾	2 75	42,237 50
5	Thomas Cisler & Co	4 09	4 09	4 09	4 50	4 19¼	2 70	43,102 50
6	Richardson, Wheeler & Monroe	4 15	4 15	4 15	4 00	4 10¼	3 40	48,442 50
7	Moore, O'Blennis & Co	4 80	4 90	5 20	5 50	5 10	2 90	49,280 00
8	David Morgan	3 90	3 90	3 90	3 90	3 90	3 75	50,250 00
9	Caius M. Cole	5 00	4 65	4 65	5 25	4 88¾	3 25	51,087 50
10	David H. Power	4 00	4 00	4 00	4 50	4 12½	4 00	53,425 00
11	Kelly & Haviland	5 25	5 25	5 25	5 25	5 25	4 00	59,050 00
12	Jolly & Hayne	4 75	5 25	5 75	6 50	5 56¼	4 25	62,662 50
13	Ford & Tierney	7 00	7 00	7 00	7 00	7 00	3 50	63,700 00
14	R. H. Gillespy	6 00	6 75	7 50	8 50	7 18¾	4 00	68,737 50

The contract was accordingly awarded to Mr. Thomas B. Townsend, of Zanesville, Ohio.

At the close of the fiscal year 549 cubic yards of dimension stone and 1,280 cubic yards of rubble had been delivered at Marietta under the above contract.

WORK DURING 1880–'81.

The river and harbor act approved June 14, 1880, appropriated $50,000 for continuing work on this lock. The approved project contemplates doing as much work as possible on that part of the lock which lies in the pool above the dam, leaving the latter undisturbed.

ESTIMATED FOR 1881–'82.

This work is one of a class that requires a definite sum in order to secure results with economy, and without undue risks.

The estimated cost of the lock is $216,400, and I would strongly urge the importance of appropriating at once the sum necessary to complete it. Unless work can be carried on with rapidity, which in such cases is synonymous with economy, it will be impossible to complete the project within the estimates.

I therefore estimate for the next fiscal year the difference between the estimated cost of the lock ($216,400) and the amount already appropriated ($80,000), or $136,400.

Money statement.

July 1, 1879, amount available	$30,000 00	
Amount appropriated by act approved June 14, 1880	50,000 00	
		$80,0[illegible]
July 1, 1880, amount expended during fiscal year	4,457 29	
July 1, 1880, outstanding liabilities	770 74	
		5,2[illegible]
July 1, 1880, amount available		74,7[illegible]
Amount (estimated) required for completion of existing project		136,4[illegible]
Amount that can be profitably expended in fiscal year ending June 30, 1882		136,4[illegible]

X 6.

EXAMINATION AND SURVEY FOR ICE HARBOR AT MOUTH OF LITTLE KANAWHA RIVER, WEST VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, January 30, 1880.

GENERAL: The river and harbor act approved March 3, 1879, directed an examination and survey at the mouth of the Little Kanawha River, in order to ascertain the adaptability of that locality to an ice harbor. The clause ordering this survey reads as follows:

Ohio River and mouth of Little Kanawha River, West Virginia: To ascertain the adaptability of that locality for an ice harbor, including a report on the cost and merit of that point compared with the mouth of the Muskingum at Marietta, Ohio, surveyed under the provisions of the act of June 18, 1878.

This survey and examination having been assigned to me, I have the honor to submit the following report:

The Little Kanawha River rises in Upshur County, West Virginia, very near the center of the State, and flows northwesterly until it joins the Ohio at Parkersburg.

The desire of the citizens of Parkersburg, at whose instance this survey has been ordered, is to utilize the mouth of the Little Kanawha as a harbor of refuge against ice in the Ohio. They assert that since the construction in 1868 of locks and dams on the Little Kanawha, the 3½ miles between its mouth and the lower dam has become a perfectly safe ice harbor, and that it only needs a small expenditure to be made complete. That slackwater dams will protect from ice is the usual experience on all rivers that have been thus improved, and I have no doubt that the statement as to the result on the Little Kanawha is strictly correct. There are others who go even further and state that no boat was ever injured while wintering in the mouth of the Little Kanawha. In Appendix A will be found a number of affidavits as to the safety of the Little Kanawa in ice floods.

The following table gives the widths and depths in the mouth of the Little Kanawha within the limits of the survey:

Cross-sections at—	Distance above mouth.	At time of survey (5′.73 on gauge).		At low-water (0 on gauge).	
		Width.	Depth.	Width.	Depth.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.in.*
Foot of Ann street	220	340	12	275	6 3
At bridge	1,100	230	*12	175	*6 3
1,746 feet above bridge	2,846	409	9 to 10	330	3 3

*Obstructed by remains of old pier.

This shows that the river is undoubtedly narrower than is desirable for the handling of fleets, but that there is a sufficient depth of water except in very low stages. The river is usually low when it freezes over, but the dead low stage occurs in the fall months, and there is always an increase in depth before winter sets in.

The remains of the middle pier of the old bridge are an obstruction that must be removed before this harbor can be fully utilized. The cross-section at the site of the bridge shows very clearly how great an obstruction it is. The top was somewhat lowered during the fall just past, but more work must be done before access to the river above the bridge can be considered as entirely safe in low-water. It is evident also that the river is too narrow to permit a coal fleet to be turned around. Any fleet entering this harbor must be untied and reformed, or it must be backed out.

The chief obstruction to the present use of the mouth of the Little Kanawha is the lack of height of the bridge that spans it ¼ of a mile above the mouth. The bottom of this bridge at its middle is 42 feet 8 inches above the zero of the gauge, and as the highest recorded high-water (that of April, 1852) reads 60.14 on the gauge, it is evident that the bridge is 18½ feet *below* high-water. While it is a reasonable answer that such a flood is exceptional, it is nevertheless plain that a bridge which is only at the level of *ordinary high-water* cannot have any spare space under it for steamboats at any stage. That this is the fact I can testify from my own experience, as I once tried to take the U. S. snag-

boat E. A. Woodruff up the Little Kanawha in ordinary low-water, but could not get her under this bridge, although the *Woodruff* is not a high boat. The difficulty was not with the chimneys, which can be lowered, but with the pilot-house.

It is evident that if the mouth of the Little Kanawha is to be fully utilized as a harbor of refuge for Ohio River boats, the bridge over this river ought to give as much head room under it as is given by the Ohio River bridges in the neighborhood.

As a rule, boats only seek such harbors during low or moderate stages, but as ice always goes out on a rising river, boats that ventured in and passed above the bridge might be unable to return until long after the ice had departed.

There are three ways of remedying this objection:

1. The government might buy and destroy the bridge.

This alternative, however, is a very objectionable one, as the bridge is a needed public improvement, and its total destruction would be a step backwards. There are a number of refineries and other industrial establishments on the west side of the river that need close communication with Parkersburg, besides the necessity of providing an easy inlet from the surrounding country. I am informed unofficially that the bridge company will sell outright for $32,500.

2. The bridge might be turned into a draw-bridge.

This alternative is also highly objectionable, as it would necessitate the reconstruction of the central pier, whose foundations are now a serious obstruction. The objection would not be so great if the basin above the bridge were so commodious and afforded so excellent a harbor as to justify a considerable outlay of time and trouble in order to reach it. Unfortunately, the mouth of the Little Kanawha is contracted, and therefore, if it is to be utilized at all, access to it must be perfectly free. I cannot therefore recommend that the present narrow channel be reduced by a large pivot pier, and that the present single span, that covers the whole width of the river, be changed into two short revolving spans. The width at the site of the bridge was only 230 feet at the time of the survey, when the gauge-reading was a little less than 6 feet; and if 30 feet of this were taken up by a pivot pier, it would leave only 100 feet on each side for navigation. As this is precisely the width of an ordinary coal fleet four barges wide, it evidently leaves no margin for leeway, and is insufficient.

The bridge company is willing to permit this change to be made at the expense of the United States, provided the latter will pay the bridge company $400 per month for the time in excess of 90 days that travel on the bridge is stopped. Their letter to this effect is annexed as Appendix B.

The cost of transforming this bridge into a draw-bridge is estimated at $30,000, it being assumed that the transformation can be made without incurring the penalty mentioned above.

3. The bridge might be raised to a sufficient height to allow boats to pass under at all stages.

As this change is to benefit steamboats that navigate the Ohio, it ought to conform to the rules that regulate the heights of bridges on that river. The act of Congress regulating bridges over the Ohio River above the mouth of the Big Sandy prescribes that they shall be 90 feet above low-water, and the bridge at Parkersburg conforms to this law. This, therefore, is the height to which the highway bridge over the Little Kanawha ought to be raised. As this bridge is now only 42 feet 8 inches

above low-water, it will require an additional height of 47 feet 4 inches in order to be on a level with the Parkersburg bridge over the Ohio.

Local circumstances are such that the utility of the bridge would be destroyed if it were raised to this height. I therefore caused estimates to be made on an assumed raising of 32 feet. The survey and estimates were made by Mr. W. E. Strong, assistant engineer, and are as follows:

HUDSON, OHIO, *January* 9, 1879.

SIR: I have the honor to submit the following report of a plan for raising the wagon bridge near the mouth of the Little Kanawha River, at Parkersburg, W. Va.

It is proposed to raise the bridge 32 feet. The estimate already submitted of the cost of doing this is based upon the following plan of operations (A):

1st. The erection of false work and removal of bridge from its present position.

2d. The entire removal of both abutments.

This course is required on account of their imperfections and improper construction.

The west abutment is badly cracked, and although strengthened by iron bands and tie-rods, is hardly secure as a support for the bridge at its present grade.

The east abutment is apparently in good condition, but the substantial portion of it is a mere shell. The entire backing was, according to the specifications in the hands of the secretary of the Little Kanawha Bridge Company, laid up dry.

The cost of the removal of the old abutment is not included in this estimate, because it is assumed as being equivalent to that of quarrying the same amount of stone, with a decided advantage in respect to haul.

3d. Building piers to the height required for the new grade.

As now constructed, the west end of the bridge is 3.7 feet higher than the east end, and the same relative height has been preserved in this plan, for the reason that thereby the long approach on the east side is made some 92 feet shorter, and a considerable saving effected in length of trestle-posts, assuming the same grade as in the plan adopted.

The assumed section of the tops of the piers is 6 by 28 feet, and the height from top of foundations 72 feet. The batter is 1 inch per foot; this gives the area of base 18 by 40 feet.

A careful computation of all strains to which the piers can be subjected indicates ample stability in one of the above dimensions.

4th. The reerection of false work and replacing the bridge in position.

I have included the cost of first putting up false work, removing the bridge from its present position, again erecting false work, and again replacing bridge in one lump sum, based upon a bill of timber required for the false work and an estimate of the cost of the work, made by Mr. G. W. Talley, the carpenter who raised the bridge when first built, viz, $4,000.

5th. The construction of approaches to each end of the bridge.

The approach on the east side is to extend a distance of 650 feet up Market street, Parkersburg.

The approach on the west side is to extend 260 feet to the bluff. That on the east side is to descend with a grade of 4 feet in 100, which will just about give under passage at Neal-street crossing.

On the west side the grade descends 5 feet in 100, which bring the roadway to the ground at a suitable point to meet a new road proposed to be built by Wood County.

As these grades are within the limits of good engineering practice for highways, the only objections that can exist to them are those of a nature connected with the construction and stability of the work.

One objection to them grows out of the horizontal strains that must be resisted by the piers. Those acting on the large piers, as has been already stated, are not sufficient to endanger their stability.

In order to relieve the iron trestles in the east approach from this horizontal strain, it is proposed to make the spans continuous each way from the ends of the approach toward the center, to fix them at the extreme ends, one to the masonry pier and the other to the abutment at the lower end of the approach, and to leave them free to expand and contract at the middle of the approach, being divided there. In this way I think that all objections on account of grades may be overcome.

Plan and estimate A suppose the approaches built of 65-foot spans, supported on iron trestles of two groups of Phœnix columns, four in a group, braced together at intervals of from 6 to 10 feet.

The trusses are of the Murphy-Whipple plan, 6 feet 6 inches between axes of chords, and the same distance for the panels. The floor-beams are I section, 28 feet long, projecting 4 feet at each end outside of the axes of the trusses in order to support a sidewalk. They are trussed. They also act as struts for the lateral bracing, and are suspended under the posts. The ties for the lateral bracing have a run of three panels.

There is an iron hand-rail on iron I-section posts for the sidewalks.

The flooring is to be of 2-inch oak plank laid obliquely, supported on white pine longitudinals 3 by 10 inches, and 30 inches between centers.

The iron trestles have a system of transverse bracing extending down 6 feet from the caps. The lower portion is left open to accommodate traffic. The bases of the columns in a group are bolted to a bed-plate of wrought iron, which in turn is either bolted to a pier of masonry or to a cast-iron anchor sunk in a pit and filled in and around with concrete and stone.

The tops of the columns are connected in a similar way to a plate that acts as a bridge-seat, and all have expansion rollers.

The strains in the upper set of five spans resulting from the horizontal components of their weight will be tensile, while those in the lower five spans will be compressive. For the purposes of estimate, these neutralize each other.

Estimate B is based upon the modification of A, which consists in substituting short spans of 16¼ feet for all but four of the 65-foot spans, viz: one on side adjoining west pier, two on east side adjoining east pier and extending over Kanawha street, and one at crossing of Neal street.

The tracing for plan B shows sufficiently the construction of the short spans. Their advantages over the long spans consist in less cost of construction and greater longitudinal rigidity, while they possess the disadvantage of interfering more with traffic.

This report is accompanied by tracings marked A and B, and corresponding with the estimates A and B, which give plan and elevation of bridge and certain sections and details.

Respectfully submitted,

Your obedient servant,

WM. E. STRONG,
Assistant Engineer.

Col. WM. E. MERRILL,
Major, Corps of Engineers, U. S. A.

Estimate A of cost of raising wagon bridge near mouth of Little Kanawha River, Parkersburg, W. Va., 32 feet, and of approaches.

Quantities.	Description of work.	Price.	Amount.
,100 cubic yards	Foundation excavation	$0 30	$333 00
17 cubic yards	Rough ashler masonry	6 00	3,102 00
,226 cubic yards	Quarry-faced masonry	8 00	17,808 00
8.4 cubic yards	Cut-stone masonry	10 00	384 00
0,088 pounds	Wrought iron in trestles	08	7,207 04
45,145 pounds	Wrought iron in 14 spans (65′ each)	10	34,514 50
4,585 pounds	Cast iron in 14 spans (65′ each)	05	3,229 25
.760 pounds	Cast iron in trestles	05	288 00
9,140 feet, board measure	White-oak flooring	015	737 10
6,844 feet, board measure	White-pine joists	02	536 88
	False work, removing and replacing 300-foot span		4,000 00
	Damages to property, south side		2,000 00
	Engineering and contingencies, about 7 per cent		5,860 23
			80,000 00

Estimate B, being a modification of estimate A, caused by substituting shorter spans in the approaches.

Quantities.	Description of work.	Price.	Amount.
,140 cubic yards	Foundation excavation	$0 30	$343 30
29 cubic yards	Concrete and stone filling for anchors	6 00	774 00
66 cubic yards	Rough ashler masonry	6 00	2,796 00
,226 cubic yards	Quarry-faced masonry	8 00	17,808 00
6.1 cubic yards	Cut-stone masonry	10 00	261 00
8,613 pounds	Wrought iron in 4 spans of 65 feet	10	9,861 30
7,087 pounds	Wrought iron in trestles for 4 spans of 65 feet	08	2,966 96
7,654 pounds	Wrought iron in trestles, 38 short spans	08	7,812 33
8,450 pounds	Cast iron in 4 spans of 65 feet	05	922 50
,057 pounds	Cast iron in trestles for 4 spans of 65 feet	05	102 85
0,980 pounds	Cast iron in trestles, 38 short spans	05	1,549 00
9,140 feet, board measure	White-oak flooring	015	737 10
4,833 feet, board measure	White-pine joists and rails	02	896 66
	False work, &c		4,000 00
	Damages, south side		2,000 00
	Engineering and contingencies		7,169 00
			60,000 00

The bridge company refuses its consent to the raising of their bridge. Their statement to this effect is annexed as Appendix C.

It will be seen from Captain Chancellor's letter (Appendix D) that the mouth of the Little Kanawha is frequently obstructed by masses of Ohio River ice, thus preventing ingress or egress. This action is less marked now than formerly, on account of the effect of the piers of the Parkersburg bridge in breaking up the large fields. It has been suggested that if a few timber and stone ice breakers were placed below the bridge, on the West Virginia side of the channel and opposite the centers of the side spans, these auxiliary piers would still further break up the masses of floating ice and help to prevent any gorging across the mouth of the Little Kanawha.

The idea is a good one, and I think that it is worth trying. The expense will be small, and if any injurious result should follow, the ice breakers can be torn up without extra cost by the government snag-boat.

I would propose two piers, composed of wooden cribs filled with rip-rap, and similar in construction to those used on the Ohio and Monongahela rivers for the protection of coal-barges. They should be placed opposite the middle points of the two short spans that adjoin the chan-

nel spans on the south, and at a distance below the bridge of from 100 to 200 feet, the exact distance to be determined when work is begun. From the action of these piers we can judge the advisability of building more or of removing these.

I would recommend that they be built to a height of 30 feet above low-water, and they be so arranged as to admit of raising if additional height should prove advisable. If we follow the experience acquired elsewhere in similar piers, we will give these a width of 22 feet and a base of 56 feet. The up-stream end should be a smooth inclined plane with an angle to the horizon of 45°. The rest of the crib can be built log-house fashion, but no ends of timbers should project from the sides.

The estimated cost of one of these piers, including engineering and contingencies, is $3,000. The two would therefore cost $6,000.

SUMMARY.

The work therefore that is needed to utilize the mouth of the Little Kanawha as a harbor of refuge is as follows:

1. To raise the highway bridge on the Little Kanawha 32 feet.
2. To remove the remains of the old center pier of this bridge.
3. To build two ice-breakers below the railroad bridge across the Ohio.

The first object cannot be accomplished without buying out the bridge company, which I consider unadvisable.

The second object should be attained by the bridge company at their own expense. They have left in the river an obstacle to free navigation which they should be compelled to remove. The law would probably hold them responsible for any damages caused by this obstruction, but the removal of the obstacle is more important to navigation than a possible mulcting of the bridge company.

The third object can be attained by the United States at the moderate cost of $6,000. I think that it is worth the trial.

The clause in the river and harbor act under which this report is made orders a comparison between the cost and merit of an ice harbor in the mouth of the Little Kanawha and one in the mouth of the Muskingum. In another part of the same act the Muskingum ice harbor is formally adopted by the appropriation of $30,000 to commence work. Under this appropriation a contract has been made for the delivery of the necessary stone.

Under these circumstances the only question left unsettled is whether, in view of the adoption of the Muskingum ice harbor, it is advisable to spend any money at the mouth of the Little Kanawha.

I would reply that the amount recommended is very small, and as the localities are 12½ miles apart, a boat might be able to seek a refuge in the Little Kanawha that could not get to Marietta. I therefore think that the work at the mouth of the Muskingum need not preclude that at the mouth of the Little Kanawha. There is no danger that the navigation of the Ohio will ever be made too safe.

This report is accompanied by a map of the locality and by a tracing showing the plan proposed for raising the bridge over the Little Kanawha.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

General H. G. WRIGHT,
Chief of Engineers, U. S. A.

APPENDIX A.

AFFIDAVITS AS TO THE SAFETY OF THE LITTLE KANAWHA RIVER IN ICE FLOODS.

1.

This may certify that I have been a resident of Parkersburg, W. Va., for over fifty years, and have been engaged in the wharf-boat business at the mouth of the Little Kanawha River for the last thirty years, and during that time there has been more or less number of steamboats put into the mouth of said stream for winter quarters, and no steamer has ever received the slightest injury from ice whilst in this harbor.

I will further state that I consider it, since the erection of the dam about four miles above the mouth, as the safest ice harbor on the Ohio River.

LEONARD CROSS.

Subscribed before me this 18th day of December, 1879.

E. P. CHANCELLOR,
Notary Public.

2.

This may certify that the undersigned have been residents of Parkersburg for the last sixty years, and during that time no steamboat, harbored in the mouth or at any point on the Little Kanawha, has ever been damaged by ice to our knowledge; and we further certify that we believe the Little Kanawha the best natural harbor (being deep) on the Ohio River.

H. LOGAN.
WM. LOGAN.
LAW. P. NEAL.
S. N. NEAL.
GEO. B. NEAL.

Subscribed before me this 18th day of December, 1879.

E. P. CHANCELLOR,
Notary Public.

APPENDIX B.

RESOLUTION OF THE LITTLE KANAWHA BRIDGE COMPANY.

At a meeting of the stockholders of the Little Kanawha Bridge Company, called by the president and directors thereof, and held at the office of Dr. A. G. Clark, in the city of Parkersburg, W. Va., in pursuance of a public notice, on Wednesday, the 31st day of December, 1879, at 10 o'clock a. m.

Present, a majority of stockholders of said company, representing a majority of the capital stock thereof, and a majority of the votes of the said company.

The president of the board of directors explained the object of the meeting, and, on motion of Dr. A. G. Clark, the Hon. George Loomis was called to the chair.

On motion of William M. Evans, seconded by Henry Logan, it was unanimously

"*Resolved*, That in contemplation of the proposition for the construction of an ice harbor in the Little Kanawha River by the United States, and in view of the fact, in the construction of such ice harbor, it will be necessary to alter the present bridge of this company across the said river at the city of Parkersburg by making the same a draw-bridge, this company hereby gives its consent to such alterations on the following conditions:

"If the crossing of the said bridge shall not be interrupted more than ninety days, then this company will require no consideration as compensation for the said bridge during such ninety days; but if such crossing shall be interrupted more than ninety days, then this company to be paid ($400) four hundred dollars per month for the time the crossing of the said bridge shall be so interrupted beyond such ninety days."

A copy from the minutes under the seal of said bridge company by its secretary.

[SEAL.]

S. C. SHAW,
Secretary, &c.

APPENDIX C.

LITTLE KANAWHA BRIDGE COMPANY TO MAJOR W. E. MERRILL, CORPS OF ENGINEERS.

PARKERSBURG, W. VA., *January* 9, 1880.

SIR: In reply to your letter of the 8th instant I have the honor to inform you that at a called meeting of the stockholders of the company held on the 31st ultimo, the question of granting permission to the United States Government "to raise the bridge, continuing it in its present form, was discussed at length and met with insur- *mountable opposition*, the main objection being the damage that would result to private property of our citizens, especially that on Market street, by reason of the elevated approach which would be necessitated by the change. The only proposition which did obtain their willing consent was the one embodied in the resolutions of which, by order of the meeting, you were furnished an official copy, viz, that of changing the present into a draw-bridge.

Very respectfully, your obedient servant,

V. VROOMAN,
President Little Kanawha Bridge Company.

Col. W. E. MERRILL,
Major Corps of Engineers, U. S. A.

APPENDIX D.

CAPTAIN E. P. CHANCELLOR TO MAJOR W. E. MERRILL, CORPS OF ENGINEERS.

PARKERSBURG, *December* 13, 1879.

DEAR SIR: In compliance with a promise made some time ago, although a little late, I write in the interest of steamboat owners, river men, and shippers on the Upper Ohio, with the view of calling your attention to the necessity of an ice harbor and, at small cost, at the mouth of the Little Kanawha River. This is probably the most remarkable stream emptying into the Ohio, as it is the only one of any size on the Upper Ohio which has deep water at all times at its mouth, and which maintains the depth for 4 miles to the first dam, giving mooring for boats for 8 miles on the two sides of this harbor. This dam spoken of is 14 feet high, and breaks the ice as it passes over, and renders it harmless to boats below it. The only trouble ever experienced heretofore, in a general break up, has been in the Ohio; ice in large cakes stopping the mouth of the Kanawha, and gorging. This difficulty has been obviated to some extent by the building of the great railroad piers, about half a mile above in the Ohio. By the erection of three additional piers between the bridge piers on the Virginia side it would entirely protect the Kanawha from gorging, and render the harbor absolutely safe. These piers would have a tendency to stop the ice early at this point and allow the ice below to flow out and give open navigation through the winter to all points below, and give boats below an opportunity of making the harbor of safety before the terrible break up from above should occur.

It would be necessary to raise the bridge now spanning the Kanawha River, say 30 or 35 feet, to give ample room for boats to go under at any stage of water. This would be better, if not cheaper, than a draw-bridge, and would not necessitate the erection of piers which would obstruct navigation. The Kanawha heads south, and does not freeze up so early nor so heavy, and it disappears much earlier than ice in the Ohio or streams heading north. There have been more or less steamboats laid up for ice in the mouth of this river for the last forty years, or since the invention of steamboats, and not one has ever received the slightest injury. This proves its absolute safety as a harbor for the protection of boats from the destructive ice floes which occur almost every winter in the Ohio River.

The cost of these improvements would be very little indeed compared to the great benefit which would ensue to the commerce to the Ohio Valley. Every facility will be offered by the citizens of Parkersburg, the bridge company, and others whose interest may in any way connect them with the improvement. The Little Kanawha has lately become a navigable stream of the United States, as also a post-route, I believe, and the bridge over it should be raised, as it is now an obstruction. This would be at least half the cost of the improvement.

Traffic has very much increased on the Kanawha since the slackwater has been completed, and several steamers are engaged in transportation and towing on it.

In conclusion I may say that the Little Kanawha is the *best natural harbor* on the Ohio River. The expenditure to perfect it has four-fifths been made in the building

of the dam before mentioned and the erection of the bridge piers in the Ohio, and I feel well assured if the matter is understood by Congress there will be no hesitation in granting the necessary funds to complete it. In doing so there will be no necessity for additional outlay in all time; no dredging, no locks to keep up, no superintendents to pay, and all this at probably one-tenth the expenditure to construct an effective or safe harbor at any other point.

Hoping that your views may not be at variance with my own, and that you may recommend favorably to the Little Kanawha, I remain,

Your obedient servant,

E. P. CHANCELLOR.

COL. W. E. MERRILL,
Major, Corps of Engineers, U. S. A.

X 7.

SURVEY OF GREEN, MUDDY, AND BARREN RIVERS, KENTUCKY.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, February 21, 1880.

GENERAL: The river and harbor act approved March 3, 1879, directed the following surveys, viz:

Green River and its tributaries, Muddy and Barren rivers, Kentucky.

This survey was assigned to me, and I have the honor to submit thereon the following report:

The drainage basin of the Green River and its tributaries may be said to lie wholly in the State of Kentucky as its overlap into Tennessee does not exceed 10 miles at the maximum. The greatest length of the basin is 175 miles, and the direction of the line of maximum length varies very slightly from the parallel of 37° 25′ north latitude. The maximum breadth of the basin, measured on the meridian of 86° 21′ west longitude, is 90 miles. The total drainage area is approximately 10,000 square miles.

Nearly fifty years ago the State of Kentucky entered very actively upon a course of internal improvement, and one of its chief undertakings was the improvement by locks and dams of the Green River and its principal tributaries. There was some delay in beginning work, but the first contract for a lock and dam on Green River was made in December, 1833. The lock and dam in question was that at Rumsey, which is No. 2 of the system. It was first opened to navigation in December, 1837.

In 1841 the slackwater system, as we now find it, was finally completed and opened to navigation. It consists of four locks and dams on the Green River, and one on its chief tributary, the Big Barren, the five giving continuous navigation from the Ohio River to Bowling Green, Ky., a distance of 175 miles. The lowest dam is at Spottsville, 8¼ miles above the confluence of the Green with the Ohio, but backwater from the Ohio gives a sufficiency of water up to lock No. 1.

The locks and dams on the Green and Big Barren are owned by the State of Kentucky, and were managed by the State until 1868.

In 1868 the Green and Barren River Navigation Company was chartered by the legislature of Kentucky, and to this company the State loaned these locks and dams for a period of thirty years. The preamble to the charter gives as a reason for this action that the works had always been a charge upon the State; that they were largely in debt, and that there was no prospect of any improvement. [These statements

are positively denied by the opponents of this charter. They assert that the State records showed at the time of the lease that the works had returned to the State treasury, above the cost of maintenance, $45,357.51. Since then the general government has paid the sum of $50,560.50 for the use and injury of this slackwater during the war. (See Appendix B.*) The company was to collect all the revenue of the improvement, and the only consideration required was that the works should be kept in repair and returned to the State in good condition at the end of the lease. The company was likewise empowered to own and operate steamboats, to buy and sell real estate, to work coal mines, to deal in the products of the country, and in general to engage in any business that they might choose. For a copy of their charter and its amendments see Appendix A.

It will at once be apparent that the navigation company is not only the practical owner of the locks and dams on Green and Barren Rivers, but that it is also authorized to compete for the business of transporting freight. It naturally used this privilege, and the necessary result was to practically drive off all boats except those owned by the company. There are but two regular freight and passenger steamboats on this line of slackwater, and they belong to the navigation company.

There was once a small subsidiary slackwater navigation on Rough Creek, built by a stock company soon after the war, but according to Mr. Baird (see Captain Fitzhugh's report), the high tolls charged by the navigation company compelled the abandonment of the Rough Creek slackwater soon after Green River was leased by the State.

That the tolls are heavy can be seen at once from a perusal of the company's charter. They are based on the *custom-house tonnage* of boats. The company's passenger boats, the Evansville and the Bowling Green, may be presumed to be as large as the locks will pass. Their registered tonnage is 159.6 and 183.57 tons respectively. The total tolls on such a boat as the Bowling Green, on a trip from Evansville to Bowling Green would therefore be as follows:

At Spottsville lock (50 cents per ton)	$91 [illegible]
At Rumsey lock (30 cents per ton)	[illegible]
At Rochester lock (20 cents per ton)	36 [illegible]
At Woodbury lock (10 cents per ton	1[illegible]
At Greencastle lock (10 cents per ton)	1[illegible]
Total one way, $1.20 per ton	220 [illegible]
Total tolls for round trip, $2.40 per ton	440 [illegible]

In addition to the above, the company is authorized to collect a toll on each passenger, but the rates are not named in the charter.

A boat of this size destined for Rough Creek would pass through the two lower locks. Its trip toll would therefore be $146.85, and its round-trip toll $293.70.

To appreciate the burden of such tolls, let us compare them with those charged on the Ohio River for passage through the Louisville and Portland Canal.

The old tolls were 50 cents per ton. Against such charges the commerce of the river protested with great energy, and ultimately succeeded in getting them reduced to their present rate of 6¼ cents per ton of *undertonnage*. As the undertonnage is only about one-half of the custom-house tonnage, the actual rate on the basis adopted for Green River is 3¼ cents per ton. This is for passing through two miles of canal and two locks.

* Omitted. See Senate Ex. Doc. No. 116, Forty-sixth Congress, second session.

While there can be no question that rates that would suffice on the Ohio would be too small for the Green, it is yet evident that the difference is too great, and that the Green River tolls are excessive.

This monopoly of transportation has naturally provoked enmity and opposition. Strong appeals have been made to the legislature of Kentucky to repeal the company's charter. In order that the situation may be thoroughly understood, I have attached copies of these memorials and of the response of the navigation company. They appear as Appendixes B* and C*.

Both sides are so fully represented by their advocates, that nothing need be added by me.

The fact that efforts in the Kentucky legislature to repeal the lease of the Green River locks and dams failed in the session of 1877–'78 (the Kentucky legislature meets biennially), shows that the present condition of affairs has its supporters and defenders. As long, therefore, as the people of Kentucky, who have the deepest interest in the matter, still through their representatives uphold the present status, it does not seem to me that the United States is called upon to interfere. But inasmuch as the Green River is *de facto* a river that is closed to general commerce, I certainly think that it has no claim upon the general government for an appropriation.

These are but individual views, and as Congress might decide otherwise, the cost of extending the present slackwater has been carefully computed:

To build on Green River eight more masonry locks with timber dams, thus adding 84¼ miles to the present slackwater, will cost	$656,144
If six of these dams are masonry instead of timber, the cost will be	714,523
To build on Big Barren River two more masonry locks with timber dams, adding 24 miles to the present slackwater, will cost	178,661
The total cost on both rivers, if all the dams are of timber, will therefore be	834,805
The total cost on both rivers, if six of the ten dams are of masonry, will be	893,184

For details reference is made to the accompanying report of Captain Fitzhugh, who made the survey and estimates.

No examination was made of Muddy River, as I received official information that it was not desired by the parties at whose instance the survey of the Green was ordered.

For such commercial statistics as could be obtained, reference is made to Appendix D.

An interesting descriptive letter from General D. C. Buell is attached as Appendix E*.

This report is accompanied by two general maps of Green and Barren rivers, respectively, and by 13 detailed maps of lock-sites.

Respectfully submitted.

WM. E. MERRILL,
Major of Engineers.

Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

* Omitted. See Senate Ex. Doc. No. 116, Forty-sixth Congress, second session.

REPORT OF MR. R. H. FITZHUGH, ASSISTANT ENGINEER.

FRANKFORT, KY., *January* 28, 1880.

SIR: I have the honor to submit the following report upon the results of the survey of the Green River and its tributaries:

This work was begun under your direction about the middle of September last, and concluded on the 29th day of November following. In this time 15¼ miles of survey were made on Big Barren River, 79¼ miles on Green River, 8 miles on Nolin River, and 6 miles on Bear Creek.

These several lines of survey followed as closely as possible the banks of the streams, and they furnish correct data concerning the meanderings and the topographical characteristics of the water-courses in question.

In the leveling department two locks and dams were located on Big Barren River, two different localities being examined for the lower lock. On Green River eight locks and dams were located, and alternate sites were examined for each of the first two locks.

In the designation of the proposed new works, the numbering of the existing locks and dams has been continued. The existing slackwater extends from Spottsville, 9 miles above the mouth of Green River, to Bowling Green, on the Big Barren. It consists of five dams, of which four are on the Green and one on its tributary, the Big Barren. They are numbered as you ascend the river, and are designated as Nos. 1, 2, 3, and 4 of Green River, and No. 1 of Big Barren.

The levels on Big Barren were all referred to the normal surface of pool No. 1 of Big Barren. On Green River they were referred to the normal surface of pool No. 4 of Green River. The low-water surfaces of these two pools, which are uppermost on these two rivers, were the starting points of the levels on the extensions.

In comparing the results of the survey made in the year 1835 by the State of Kentucky with those just obtained, I find the following disagreements. The distance on the Big Barren from Double Springs to the mouth of Drake's Creek is 12 miles according to the old survey, and 13.8 miles according to the new. The latter measurement is correct, as was proven by a check line run so as to connect the termini of the survey. The distance on Green River from the mouth of Bear Creek to the mouth of the Little Barren is 77.5 miles by the old survey and 79.25 miles by the new; this difference can easily be accounted for on the supposition that one line conformed more nearly than the other to the margin of the river. Having no means of determining the planes of reference used in the old work, I cannot report definitely the difference in the levels of the two surveys, but as between given points I find minor disagreements all along the line of survey, resulting in a difference of 3.75 feet in the rise from the mouth of Bear Creek to the mouth of Little Barren, a distance of 79¼ miles. Having run no test levels, I cannot say that the recent work is free from error. But as a negative argument in favor of the late work, it may be proper to state that I found in the section embraced between Dam No. 4 of Green River and the mouth of Nolin River a seeming error of 6.5 feet in the old survey. According to the levels reported at the time of construction, the existing dam No. 4 should have given 1¼ feet of pool water at the mouth of Nolin. In fact, it does not reach the plane of the low-water surface at that point by 5 feet. And yet, as before indicated, being ignorant of the datum heights of that survey, I am unwilling to pass judgment upon its accuracy.

The work of selecting and examining sites for locks and dams was prosecuted as nearly as practicable in the manner generally prescribed in your letter of instructions.

Except in the case of the two dams next below the Mammoth Cave, the lifts were made 12 feet each.

The locations of the dams were determined by considerations of ample width and straightness of river, depth of water-cushion below the dam, and character of bottom and banks. Whenever the question of tributary navigation was involved, I endeavored to meet the demands of the case by locating alternate dams, one in each instance being below the mouth of the stream to be thus rendered navigable. In the particular examination of each site, from four to ten transverse sections of the river were taken, 100 feet apart, by means of a line marked every 25 feet and stretched across the river; along this line soundings of the water were taken at each tag and recorded. The character of the bottom was tested by means of a drill 12¼ feet long, which was driven to the rock, or as deep as it could be forced into the compact strata below. Three or more of these borings were made on each section; and in every case the outline of the rock was determined where it existed at all. These cross-sections were continued to a height of 20 or 30 feet above the water surface on either bank; and in cases where slips had occurred, the depth to the underlying rock was ascertained as accurately as was practicable under the circumstances.

By such means the site for dam No. 2 on Big Barren River was located at Underwood's Ferry, three-fourths of a mile below the Bowling Green steamboat-landing, with an alternate location just below the Warren County Iron Bridge, one-third of a

mile above said landing. Dam No. 3 was located 800 feet above the mouth of Drake's Creek, 14¾ miles above No. 2.

On Green River, dam No. 5 was located at Floyd's Landing, 20½ miles above No. 4, with an alternate location 2,000 feet below the mouth of Bear Creek and 18 miles above No. 4. No. 6 was fixed at a point 1¼ miles below the mouth of Buffalo Creek, with an alternate location just below the mouth of Nolin River, 13 miles above No. 5 and 3¼ miles below No. 6. Dam No. 7 was located 1 mile above Mammoth Cave and 11 miles above No. 6. Dam No. 8, at Saunders's Ripple, 10 miles above No. 7. Dam No. 9, at Hazelip's Bend, 9 miles above No. 8. Dam No. 10, at the head of the island, three-quarters of a mile above Munfordville and 7¼ miles above No. 9. Dam No. 11, at a point 600 feet above the Burnt Bridge, at the crossing of the Bardstown and Glasgow Turnpike, and 10¼ miles above No. 10. Dam No. 12, half a mile above the mouth of Lynn Camp Creek.

The pool created by the present dam, No. 1, on Big Barren River, extends 4 miles above the Bowling Green Landing, ending at the apex of a horseshoe bend, which incloses a peninsula 10 miles around. Through the neck of this peninsula there seems to be an underground passage for a portion of the water of the river. The issue of a copious stream of water, known as the Double Spring, immediately above the Bowling Green Landing, cannot be accounted for upon any other hypothesis. This water is unlike that which flows from other springs in the vicinity, and in taste and temperature is almost identical with that of the river. But, beyond this, the sympathetic fluctuations of these springs with the water surface of the river, and the absence of any sufficient watershed to supply such a flow, afford almost conclusive evidence that the source is a higher level of the river itself. Just above this issue of water there is a shoal some 600 feet in length, on which there is a depth of but 2¼ feet in the dry season.

There is a partial objection on the part of the Green and Barren Navigation Company to the site at Underwood's Ferry, because of the inconvenience of having a lock just below their Bowling Green landing. To afford an opportunity of meeting this objection, and for the purpose of submitting to your consideration a choice of sites at this important point, I made a careful examination of the river and its bed-formations at the head of the shoal just mentioned. In respect to width and suitability of bluffs no objection can be urged against this locality; but, having found no rock anywhere in the whole width of the river, by means of a rod driven 12 feet into the formation below, I would be loath to select this as a point for the location of a lock and dam; for the sufficiency of an artificial foundation for a lock can, after all, only be determined by the practical working of the lock itself. Another and very serious objection is the probability, which almost amounts to a certainty, that the underground passage through the peninsula would so draw down the pool under the influence of the additional head that it would be impossible to keep it full in the dry season.

For these reasons I was reluctantly compelled to select Underwood's Ferry as the only available site for lock and dam No. 2. At this location, although there is no continuous rock bottom, the conditions are otherwise very favorable for the construction of a dam. No little difficulty, however, must be encountered in the founding and erection of the lock walls, the bottom of which will probably rest upon rock at a depth of 14 feet below the normal surface of the existing pool No. 1. On the other side they will encroach heavily upon the low rock bluff constituting the left bank of the river. The extent of these difficulties can be best appreciated by reference to the estimates which accompany this report, and by an examination of the plat for that site.

In the selection of a site for dam No. 3 on Big Barren River, I was governed solely by considerations of the fitness of physical conditions. At first view, it seemed desirable to place the dam at the mouth of Drake's Creek, so as to afford to that tributary all attainable navigation; but having ascertained that the lift of water which would be thus occasioned would cause the overflow of the bottom lands along the creek, and that it would afford but a few miles of unimportant navigation, I abandoned the idea and selected the site above the creek. On this portion of Barren River I have been unable to find any place at which a rock bottom extends entirely across the river, nor, indeed, could I find a place where it extended far enough out to give room for a lock without cutting, to some extent, into the contiguous bluffs. How far it is judicious to chamber into the bluffs rather than go to the deeper rock bottoms farther out in the river, is a question that can only be determined by investigations of the most critical character. For myself, I would "rather bear those ills we have, than fly to others that we know not of."

On this principle I have chosen to encroach so far on the rocky bluffs as to permit the outer lock walls to rest upon the rock bottoms. A glance at the plats of the dam-sites will show how far, in each case, it is designed to cut into the bluff. The narrowness of the river at the Drake's Creek site is an objection, but it could not be obviated

by going elsewhere, except at the sacrifice of other more important conditions, such as straightness of river and rock bluff and bottom.

Beyond the mouth of Drake's Creek the survey was continued but one mile, partly because it was thought more important to devote the remainder of the limited time allotted to this work to the examinations of Green River, but mainly because such a course was more in harmony with the tenor of the general instructions which were to guide me in the execution of this work.

On Green River it was my purpose to have located dam No. 5 below the mouth of Bear Creek, so as to have given a maximum amount of navigation to that stream, but examinations below the mouth of the creek satisfied me that no desirable location could be found. Where the alignment of the river was satisfactory, rock bottoms could not be found; and where rock was found the river was too crooked or too narrow. Mainly for these reasons, I discarded the idea of trying to benefit the navigation of Bear Creek as a prime consideration, and, going above, fixed the site at Floyd's Landing, not far from the head of the pool created by the present dam No. 4. This point is two miles above the mouth of Bear Creek, and 20¼ miles from dam No. 4. After making this selection, I was gratified to learn, from the reports of 1836, that identically the same site had been determined upon by Alonzo Livermore, the engineer at that time in charge of the slackwater improvement of the Green and Barren rivers. Experiments made then led to the belief that rock, at a feet few below the gravel bed, stretched entirely across the river. The result of my investigations, however, did not fully confirm this opinion. I found rock extending out about 75 feet from the right shore, but beyond that I bored for it in vain to a depth of 10 feet. There is room here for founding the lock on solid rock without having to encroach materially upon the bluff. The river is nearly straight, the bluff on the right side is high and rocky, and on the left side the bank constitutes the termination of a bottom about one-fourth of a mile wide and 40 feet high. The depth of pool No. 4 at this point is 6 feet, and it affords a good cushion from the overflow of the proposed dam.

The alternate for this site was located in the wide, straight stretch, which, beginning at the mouth of Bear Creek, extends for a distance of three-fourths of a mile below. Soundings and borings made here developed a very favorable condition of water depth, but no rock was discovered anywhere on the bottom or the banks. The gravel, however, which constitutes the bottom formation, is hard to penetrate, being very compact and unyielding, and might with some artificial assistance be made a satisfactory foundation for both lock and dam. With such a presentation of the case you may the better decide upon the expediency of entering upon the development of the resources of coal, iron, and timber on Bear Creek by the adoption of this site for dam No. 5. Dam No. 6 is located 1¼ miles below the mouth of Buffalo Creek on the straight stretch 3,000 feet long. At the dam-site the river is 170 feet wide, with a bold, high rock bluff on the left side, and an alluvial bank 30 feet high on the right side. Here the river rests upon a rock bottom all the way across, with a depth varying from 0 to 6 feet below the gravel covering. As in every case so far mentioned, the lock at this site is located on the bluff side. This is done primarily because of the convenience of the position of the rock, but also because I am informed by the superintendent of the Green and Barren Navigation Company, Capt. John A. Robinson, that his active experience of twenty years or more on these rivers satisfied him that the current side, which is usually the bluff side of the river, is in all respects the best for the location of the lock, principally, he says, on account of the advantage derived from the scouring action of the water, which keeps the chutes cleaned out. The normal depth of water at this point is 5 feet, which will be augmented by 4 feet due to the dam below, and thus we will have a cushion of 9 feet.

As an alternate for this site, and in order to effect the greatest extent of navigation on Nolin River, I made a location just below the mouth of that stream. The river along here is quite direct, and has a width of 170 feet at a very low stage. On the right side there rises up a steep bluff of rock; on the left side the bank is 30 feet high, and is entirely alluvial in its character. Rock is found to extend 75 feet out from the right shore, thus affording room for the founding of the lock-walls. The depth of gravel over the rock varies from nothing to 5 feet; the depth of the water at a low stage is 5 feet, making, with the backwater from pool No 5, an ultimate cushion of 11.5 feet. The chief objection to building at this point is the increased height to which it would be necessary to raise the dam, being 3 feet more than would be required at the upper site to reach the same height of pool.

Dam No. 7 is located 1 mile above the Mammoth Cave, near the upper end of a high narrow island about one-half a mile long. Here we find every condition necessary to a perfect site for a lock and dam. The river is straight and wide, with a rock bluff on either side. Rock bottom was found as far out as could be tested by the limited means necessarily incident to such a survey; that it constitutes the entire bed of the river at this site, I think is a most reasonable and safe inference. The island is separated from the right bank of the river by a long, perfectly straight chute, about 40 feet wide at

low-water mark, and containing at low stage a depth of 2 feet. In this chute a rock bottom was struck after penetrating an overlying bed of gravel some 6 feet in thickness. The river at this point, including the width of the island and chute, is 500 feet wide. After the lower pool shall have been created, this dam will have a water cushion of 12 feet across the channel of the main stream, and otherwise will have an island backing gradually rising to the full height of the dam. To reach this point dams Nos. 5 and 6 were each designed for lifts of 13¼ feet, by which arrangement the mouth of the stream discharging from the Mammoth Cave was passed at as low a level as was practicable without a resort to expensive dredging. From trial levels run first from the surface of low-water in Green River up to the mouth of the cave and then down to the surface of the lowest water in the cave I find the rise to the mouth of the cave, and the descent in the cave, to be in each case about 229 feet, thus showing that the river and the cave waters are on the same level. The outside work was tested and found to be correct; that in the cave may be in error a few tenths, on account of the difficulty of running an accurate line through the tortuous passages, but the result cannot be greatly inaccurate, as was sufficiently tested by a rapid proof line run over a different route. A careful observation of the effects of a slight rise in the Green River convinces me that no material damage to any route in the cave will result from the slackwater herein contemplated.

Dam No. 8 is located at the head of Saunders's Ripple, and at the upper end of a small island. Here the river is straight for fully 1,000 feet each way, and it is generally 200 feet wide. The rock bluff on the right side rises boldly to a height of over 200 feet; on the left the alluvial bank attains a height of 30 to 40 feet. Because of the strong current in the river at the time of this examination, and on account of the difficulties of boring through the gravel, I did not succeed in penetrating to the rock anywhere in the bed of the river; but having found it on both sides near the margin of the water at a maximum depth of 7 feet below the surface of the overlying gravel, it is quite probable that it will be found within reach across the entire width of the river. Although I had designed the lock for the right bank, yet there would seem to be no difficulty here in locating it on either side. The water cushion for this dam will be 7 feet.

Dam No. 9 is located near the apex of Hazelip's Bend, at the head of a ripple, and at the upper end of what is known as Boat Island. This point is favorable for the construction of a dam, because there is underlying a covering of 3 or 4 feet of gravel, a continuous rock bottom, admitting of the founding of the lock on either side of the river. Following my invariable rule, I have in this case also located the lock on the bluff side of the river, which is here the left bank. But should it ever be thought expedient to allow a wider channel for the passage of the water, it might be found practicable to push the lock wall into the alluvial bank on the right shore, and still rest it upon a rock foundation. The river being practically straight, the direction of the current is favorable to either location.

Dam No. 10 is designed for a site three-fourths of a mile above the ferry at Mumfordville, where the river is 200 feet wide. As in the case of the site immediately preceding, this location is on a ripple at the head of a long island; here also we find a continuous rock bottom from 1 to 5 feet under the gravel. The rock bluff rises quite abruptly from the right shore, and on the left shore we find the almost invariable sedimentary flat standing from 30 to 40 feet above low-water. This dam is located near the middle of a straight stretch several thousand feet in length, and in a natural depth of water at lowest stage of 3½ feet; which, being augmented by the addition of 4½ feet from pool No. 9, gives 8 feet of water on the lower side of the dam. The lock is located on the right bank.

Dam No. 11. In making this location I had to choose between two points of about equal merit, one being just above and the other just below the burnt bridge or crossing of the Bardstown and Glasgow Turnpike. After balancing natural advantages, I was determined in favor of the upper site by considerations effecting the milling interests existing at this point. The dam, if located above, does no harm; if below, it would cause the drowning out of one of the mills, with little, if any, compensating advantage. The depth of water here at lowest stage is from 3 to 6 feet; the bottom is rock underlying from 0 to 6 feet of gravel. On the right bank the mountain descends rapidly to the river, forming almost a cliff of rock. The left bank is of alluvial formation, and not so high as usual, being 25 feet above low-water. If dam No. 10 were in existence there would be here a water cushion 8 feet in depth. The river curves gently in a uniform width of 175 feet. The lock is located on the right side.

Dam No. 12 is located at Harlow's Ripple, half a mile above Lynn Camp Creek. Here I found the whole volume of the river running in a channel 75 feet wide and 1 foot deep. The dam is designed to occupy a position just above this narrow channel, where there is a depth of 3 feet of water in the dryest season. A rock bottom under the gravel covering, which varies in thickness from 0 to 3 feet, extends out from the left shore to a distance of from 75 to 125 feet, as determined by the trying-rod. Under

a more searching test, I am of the opinion that the rock bottoms will be found to extend to a uniform distance of 125 feet or more, and that nowhere will the gravel covering exceed 10 feet in depth.

With pool No. 11 full, there will be a depth of 6 feet of water on the lower side of this dam. At this point the river is full 200 feet wide, and straight for 1,000 feet above and below. The bluff on the left side is very precipitous, and presents an almost bare face of rock. The right bank is the termination of what was once a series of islands, now joined one to another, and so extending to the mainland. This formation is nowhere along the river margin less than 25 feet above low-water level, and I regard it as being as safe an anchorage for the end of the dam as the average alluvial bank of the mainland. The lock is located close in to the bluff on the left side. The pool created by this dam will add 11 feet to the depth of the water at the mouth of Little Barren at its lowest stage; and, according to the survey of 1835, it will extend up the Green River to a point 4 miles above the confluence with Little Barren and up the Little Barren for a distance of 2¼ miles.

Here the survey was discontinued on the 13th day of November, on account of the lateness of the season. But even had the season permitted, it is questionable whether it would have been judicious to have much further extended examinations upon the headwaters of a stream which are descending at the rate of 2 feet per mile on the main branch, and 3 feet per mile on its principal tributary, the Little Barren. In the possible further prosecution of this survey at some future day, it may be found advisable to estimate for slackwater as high up as Greensburg, the county seat of Green County, which is situated on the river 25 miles above the mouth of Little Barren; but of this you will be enabled the better to judge after examining the evidence herein contained.

The accompanying tables give the chief results of all the recorded surveys that have ever been made on Green River and its tributaries. The titles of the tables sufficiently indicate their contents. Table E has been prepared in order to show the cost of using masonry instead of crib dams at sites Nos. 6, 7, 8, 9, 10, and 11 on Green River. These points have been selected for stone dams because of the presence of continuous rock bottoms at available depths. As a convenient and safe basis of calculations for this character of dam, I have adopted the rectangular section with a thickness, in every case, equal to the lift of the lock. In constructing, this section will admit of such reductions as may be thought judicious. I think that building-stone of a satisfactory character may be found at no great distance from each of the sites in question. Indeed, in the matter of building-materials generally, I see no grounds for apprehending any difficulty. In this department no special investigations were made, but enough was observed in the variety of limestones everywhere present to satisfy me that good material for every description of stone work necessary to this improvement might be readily had. On the river banks, or in close proximity thereto, timber of the requisite size and character, may be found always convenient.

The character of dam upon which the general estimate has been made is a modification of the ordinary crib-work, having an upper slope with a base of 16 feet, and a lower slope always reaching to the surface of the pool below, with an inclination of 1 on 4. Thus the total width of the base of the dam is from 64 to 70 feet, according as the lift is 12 or 13¼ feet. These dams are designed to be of round logs not less than 1 foot in diameter, built in pens 8 feet square, and bolted together with 1¼-inch round iron. The pens are to be filled with broken stone or large gravel, and the whole dam is to be backed with sand calculated to a slope of 1 on 3.

The locks are designed to be built of ashlar and good ranged rubble masonry; 5¼ feet from the inner faces being taken as the average thickness of the ashlar, and the rest of the walls as rubble. As instructed by you, I have estimated for locks of the same capacity as those existing on this river, and in full recognition of the value of the guide of experience, I have very freely referred to the original manuscript specifications for the old works (luckily in my possession), upon which locks now standing in all of their integrity were constructed nearly forty-five years ago. The dimensions of these locks are as follows: Length of chamber between hollow quoins, 160 feet; width of chamber, 36 feet; total length of lock walls, 214 feet; river wall, 12 feet thick with vertical faces; land wall, 12 feet at bottom, 6 at top from recesses to ends of wall, and 4 feet between recesses. I have estimated for gates and fixtures similar to those at present used on this river, but shall submit with this report a sketch of an improved gate, the device of Capt. John A. Robinson, the superintendent of the Green and Barren Navigation Company. He assures me that he is now using this gate with great satisfaction.

The substitution of iron plates for miter and heel posts, and the collar arrangement by which the gate swings, seem to be the chief points of merit. It strikes me as being a compact, simple construction, of many excellencies, and much superior to the contrivance which it replaces. It will be observed that timber foundations have been calculated for every lock. In point of fact, this item is in excess of a theoretical esti-

mate, for in every case the stone work is assumed to rest upon the rock bottom, and the estimate is made accordingly. Whenever a timber bottom is designed to go in, its depth might be taken from the height of the walls; and yet such are the known uncertainties of preparing foundations, and such is our ignorance of what is under water, that the error, if any, of this provision will be on the side of safety, and therefore the more admissible. I adopted this plan of estimating in order to provide for the contingency of having to go deeper with the excavations for the lock walls. An accompanying sketch will help you to a clearer apprehension of what has been said concerning the dimensions of the existing form of lock, which constitutes the model herein adopted.

The estimated cost of the whole improvement, on the basis of crib dams, is $834,805; if stone dams are substituted, as hereinbefore indicated, this estimate will be increased by the sum of $58,379, and will stand $893,184. The unimportant difference between the cost of the crib and stone dams, except in the case of the site at Mammoth Cave, would certainly suggest a more careful investigation of those cases prior to the adoption of either plan of structure.

The water shed of Green River embraces about 9,600 square miles, and includes portions of 29 counties. Practically, one-half of this area is above existing slackwater, and is a country rich in the excellence and variety of its timber, and in the growth of the finer grades of tobacco. In 1834, 1835, and 1836 the development of this country received a great deal of attention. Surveys were made almost to the headwaters of the various streams tributary to the Green, and reports were made favorable to slackwater improvement to the utmost limit of practicability. At that time there was a popular idea that a connection between the headwaters of the Big Barren and a tributary of the Cumberland was entirely practicable, and that it should by all means be made in the interest of internal commerce. This question was finally disposed of in the following report, made at that date by William B. Foster, the assistant engineer in charge of the slackwater improvement of the Green and Barren rivers:

"The survey was commenced at the mouth of Peters Creek and carried up the Barren River to the junction of the East and Long forks; thence up the East Fork to its source; and thence to the summit of the ridge. A crest line was then run from this point southwardly to the Tennessee line, a distance of about 13½ miles. The lowest depression was found to be at Glenn's Gap, between the headwaters of Mill Creek, a tributary of the Barren, and Sulphur Lick, a tributary of the Cumberland River. The bench-mark at this point was 462.75 feet above the low-water plane of Barren River at Peters Creek. A line was carried from this bench-mark down the valley of Mill Creek and connected with the line along the East Fork, and down a ravine to the forks of Sulphur Lick Creek; thence down this stream to the Cumberland River. The descent to the low-water plane was found to be 466.79 feet, or about 4 feet lower than the Barren at Peters Creek. Between Peters Creek and the junction of the Long and East forks, a distance of 30 miles, the river runs through a narrow valley which seldom exceeds one-fourth of a mile in width. Its channel is generally along the side of the valley at the base of the hill or rock bluff, but it frequently changes from one side to the other. The width of the river at the mouth of Peters Creek is 220 feet; it diminishes to 140 at the junction of East and Long forks. The ascent in this portion of the river is 89.6 feet, or about 3 feet to the mile. The height of the flats or bottoms above low-water surface does not exceed 15 feet, and is frequently less. These bottoms are occasionally overflowed to a depth of 4 or 5 feet, and sometimes more. The distance from the mouth of the East Fork to the mouth of Mill Creek is 16 miles, and the ascent 90.54 feet, or about 5.64 feet per mile; hence along the valley of Mill Creek to its source, the distance is 8 miles and 4,260 feet, and the rise 98 feet, or at the rate of about 11.2 feet in a mile. From the summit bench-mark down the river to the fork of Sulphur Lick Creek, the distance is three-fourths of a mile, and the descent 302 feet, or at the rate of 402.66 feet per mile; thence along the Sulphur Lick Creek to the Cumberland River the distance is 4 miles and 1,920 feet, and the descent to the low-water plane is 164.79 feet, or about 37.5 feet in a mile. The quantity of water in the Barren River as far as the mouth of Line Creek appears to be sufficient to supply a well-made canal or a navigation by slackwater with well-constructed dams. The river is not well adapted to the latter kind of improvement, as it has a good deal of descent, and the bottoms are too low to admit of the erecting of dams sufficiently high to give the desirable lifts to the locks. A canal could be made at an expense of about $35,000 per mile. A canal could be extended up the East Fork about 14.75 miles to the mouth of Line Fork. Above this point the quantity of water would not be sufficient for the purposes of navigation. From the mouth of Line Creek to the summit bench-mark at Glenn's Gap the distance is about 13 miles and the ascent 313 feet.

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"From the summit bench by the valley of Sulphur Lick Creek to the Cumberland River, the distance is about 5.1 miles, and the descent 466.[illegible] feet. This part of the route is not adapted for a canal. * * * A reconnaissance was made of the ridge eastward as far as the Burksville and Glasgow road for the purpose of ascertaining

whether a depression lower than Glenn's Gap could be found between the waters of Skegg's Creek and Marrowbone Creek. The lowest places in the dividing ground between these streams appeared to be as high as or higher than the summit at Glenn's Gap.

"It appears from the surveys and examinations which have been made that a water communication between the Barren and Cumberland rivers is impracticable."

In relation to the particular resources of this great watershed, the largest in the State, I think it best to refer to the testimony of Prof. N. S. Shaler. In his special report upon the Nolin River and Bear Creek districts, he says:

"The task of the western party of the survey for this year has been to determine the character of the deposits of coal and iron in the easternmost part of the Green River coal field.

"So far our efforts have been richly rewarded. In the section where our work has hitherto lain, in the territory between Bear Creek and Nolin River, and for a certain distance to the east and west of those streams, we have determined the position and character of sources of supply for furnaces and coal mines unexcelled by any in the State. At least two veins of workable coal, of good quality for steam purposes, and sufficient thickness for profitable working, have been satisfactorily determined.

"One of these veins is 4 feet in thickness; seems to carry its thickness well: is admirably disposed for drainage, and could be mined as cheap as any coal in Kentucky. Analysis seems to show that it will answer well for making coke suitable for iron smelting.

"The point of most interest, however, is the rich and extensive series of ore beds which have rewarded our search. Not less than five different beds appear at various points in the heights of the hills. Of these, one, a bed of 3 to 5 feet, or more, in thickness, of oolitic ore, contains about 37 per cent. of iron, in a very favorable combination for making metal of good quality. This bed has already been traced over an area of about 20 square miles, and will in itself furnish ore for 50 furnaces for centuries to come. Two other ores promise good results, though, owing to the densely wooded condition of the country, we have not been able to trace them out the whole area as well as the overlying oolitic ore.

"The timber in this section is of excellent quality for the uses of the miner and iron-worker. There is an abundance of wood suitable for charcoal and for the supports of mines, &c. Limestone, of excellent quality for furnace use, is found at the base of the hills, and stone suitable for the masonry of furnaces can be had at every point.

"I am thoroughly satisfied that this region is full of promise, and that it only wants capital and energy to give it development. With the revival of the iron industry from the late panic, a restoration which seems just at hand, I am confident that this region will come to the knowledge of the world. * * * * *

"Here is a noble river, with unfailing water-power, and with 4,000 square miles of the best coal and iron in the West, a good soil, noble forests of manufacturing woods and a good climate.

"THE NOLIN RIVER DISTRICT.

"In Edmondson and Grayson Counties, north of Green River, between Nolin River and Bear Creek, is an area of considerable size, called the Nolin River district. The ores of this region are stratified carbonates and limonites, found near the base of the coal measures. The ore of most value occurs above the conglomerate. It is about 4 feet thick, and, so far as present developments indicate, underlies an area of large extent. It is almost wholly undeveloped. A number of years since a small charcoal furnace was established on the Nolin River, but it was so far from market, and transportation of the iron was so expensive, that the enterprise soon failed. It ran long enough, however, to establish the fact that an excellent iron could be made from these ores.

"The following analysis, by Dr. Peter and Mr. Talbutt, shows the quality of a sample of this ore from near the head of Beaver Dam Creek, in Edmondson County:

Iron peroxide	52.985
Alumina	4.725
Manganese	.210
Lime carbonate	.100
Magnesia	.435
Phosphoric acid	.356
Sulphuric acid	.143
Silica and insoluble silicates	30.540
Combined water	10.400
Total	100.011
Metallic iron	37.045
Phosphorus	.154
Sulphur	.057

"In addition to the great amount of timber available for charcoal, stone coal occurs in the same region. This coal is lowest of the series, and is of most excellent quality, analysis showing it to be far superior to the higher coals of Western Kentucky, which are the ones most generally mined. The region is now more accessible than formerly, as it lies within 15 miles of the Louisville, Paducah, and Southwestern Railroad, but the lack of transportation facilities directly to it has prevented its development.

"The aggregate amount of ore, coal, and timber suitable for charcoal in this region is immense and offers great opportunities for development. It is one of the most richly endowed undeveloped iron regions of the State.

"In many other localities in the western coal field, iron ores have been found, but they have not been thoroughly prospected, and little is known of their extent. One of the best known localities of this sort is in Muhlenburg County. In this county are found, at Airdrie Furnace, on Green River, and at Buckner Furnace, near Greenville, deposits of so-called black-band iron ore, a ferruginous bituminous shale, yielding about 30 per cent. of iron. At Airdrie Furnace this coal rests immediately above an excellent coking coal, and the two can be mined together very cheaply.

"At this place iron can be produced very cheaply by bringing ore from the Cumberland River region and using it in admixture with the native ore.

"For a more detailed description of this locality, see report in second volume, new series, Kentucky Geological Reports, on the Airdrie Furnace."

The mineral wealth of the Green River Valley as a whole can be best understood by a careful examination of the following tabular statements of iron and coal. These statements are collected from the various reports of the State geologist, and carry with them the full weight of that high authority.

Table of iron ores

County.	Locality.	Kind of ore.	Specific gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of manganese.
Butler	Woodbury	Carbonate	3.026	....	70.200	...
Ohio	Hartford	Limonite	....	39.480	....	[illegible]
	Livermore	do	....	60.180	....	[illegible]
Grayson	Big Caney and Little Clifty Creek	do	....	63.600	....	[illegible]
Edmondson	Nolin Ore Bank	do	....	60.900	....	[illegible]
	Nolin Iron Works	do	....	74.700	....	[illegible]
	W. B. Morris	do	....	62.120	....	[illegible]
	Nolin Iron Works	Carbonate	3.507	....	65.120	....
Warren	Clay Lick Creek	Limonite	....	67.140	....	[illegible]
Butler	Alum Spring	Carbonate	3.490	7.190	65.960	..
Muhlenburg	Hawes Ridge	Limonite	2.571	....	....	[illegible]
	Old Furnace	do	.283	....	....	[illegible]
	Kincheloe's Bluff	do	3.460	....	....	[illegible]
	Turner's & Buckner's Old Iron Works	Carbonate	3.110	....	64.870	......
	Williams's Landing	do	3.190	....	62.420	....
	Battist Creek	do	2.940	....	64.900	.
	Fordswell	do	2.924	....	74.460	..
	Slate Bank	do	3.218	....	54.320	..
	Slate Ore Bank	do	3.289	....	62.590	......
	Greenville	do	2.520	....	85.000	[illegible]
	Hoskin's Muddy Creek	Limonite	....	....	....	[illegible]
Edmondson	B. Merideth	do	....	55.028	....	[illegible]
	Sycamore Creek	do	....	76.284	....	[illegible]
	Nolin Furnace	do	....	....	....	[illegible]
	Beaver Dam Creek*	do	....	52.926	....	[illegible]
	Near Nolin Furnace	do	....	27.340	....	[illegible]
Muhlenburg	Airdrie Furnace	do	....	63.048	....	[illegible]
	J. M. Hopes	do	....	60.492	....	[illegible]
	Do	do	....	46.866	....	[illegible]
	Greenville	do	....	69.546	....	[illegible]
	Airdrie Furnace	do	....	59.810	....	[illegible]
Grayson	Near Nolin Furnace	do	....	57.830	....	[illegible]
	Taylor's Ford Beaver Creek	do	....	44.528	....	[illegible]
	J. H. Higdon's	Clay, iron, stone	....	6.536	60.466	..
	West of Beaver Creek	do	....	42.761	19.596	.
Butler	John Hudson's	do	....	17.945	29.914	.
	Knob Lick	do	....	17.313	22.563	.
Muhlenburg	Airdrie Furnace	do	3.376	9.054	47.810	.
	Buckner's Furnace	do	....	29.618	42.950	....
	Jerry Hope's Bank	do	....	18.374	26.645	..
Grayson	Rock Creek	Limonite	....	27.192	....	[illegible]
Butler	J. E. Taylor's	do	....	48.040	....	[illegible]
	Stevens's Coal Mines	do	....	44.794	....	[illegible]
Ohio	Dooring's Bank	do	....	55.337	....	[illegible]
	Do	do	....	56.972	....	[illegible]
	Mrs. K. Inglehart's	do	....	18.676	....	[illegible]

* Not estimated.

of Green River.

Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid.	Sulphur.	Potash.	Soda.	Combined water.	Insoluble silicates and silica.	Oxide of iron.	Carbonate of manganese.	Sulphurous acid.	Bituminous matter.	Percentage of iron.
2.550	7.040	1.510	.640	trace	.420	.010	....	7.650	9.920	1.600	......	......	39.450
a trace	1.120	1.810	.640	......	.340	.060	8.280	47.370	......	......	......	......	27.640
a trace	.730	4.850	.600	......	.400	.080	13.140	19.750	......	......	......	......	42.140
..270	1.220	2.360	.890	......	.250	......	12.020	19.150	......	......	......	......	44.540
a trace	1.150	.650	.570	......	.360	.320	11.150	23.680	......	......	......	......	42.640
a trace	.150	.450	.550	......	(*)	(*)	11.190	12.650	......	......	......	......	52.310
a trace	.290	2.450	.430	......	.380	.420	13.250	20.550	...	......	0.060	......	43.500
1.950	8.450	.950	.360	0.100	.570	.050	....	9.170	7.980	1.830	.670	2.890	37.040
.270	.670	.800	.860	......	.370	......	11.160	17.950	......		......	......	47.020
5.900	6.030	....	2.640	......	.230	.060	.690	8.700	......	1.570	......	1.030	36.900
.050	.530	2.700	.310	......	.360	.120	11.200	35.900	48.700	.....	.....	......	34.100
.390	.250	2.520	2.650	......	.210	.030	11.500	19.300	62.200	......	......	......	43.560
.440	.200	1.870	.630	......	(*)	(*)	11.000	25.100	60.700	.....	......	......	42.500
3.580	4.260	.670	.930	......	.230	.280	.900	16.250	4.390	1.090	......	1.400	34.180
3.650	7.410	.950	.100	......	.230	.120	1.570	15.270	3.380	2.490	......	2.420	32.520
3.250	6.570	.600	.350	......	.170	.520	.110	7.070	7.410	1.180	......	7.870	36.540
2.450	4.700	.700	.380	......	(*)	(*)	1.230	5.950	1.150	1.030	......	7.900	36.800
3.870	2.970	.500	.530	......	.080	......	1.910	21.940	6.750	2.680	......	4.440	31.170
2.670	4.690	1.870	a trace	......	.230	.120	1.030	8.190	14.790	1.420	......	2.400	40.260
....	1.150	.157	.350	......	.380	.....	.460	7.950	.....	.....	......	3.140	....
a trace	.615	1.000	1.591	......	.154	.106	11.300	16.980	67.340	......	6.800	......	47.159
a trace	1.080	1.006	3.120	......	......	......	8.300	35.180	......	......	.133	......	35.519
180	.068	2.361	1.055	......	......	......	12.000	7.950	......	......	.151	.....	53.399
1.180	.419	2.057	2.423	......	.201	.066	9.670	45.670	37.240	......	.544	......	26.039
.180	.425	4.792	.355	......	......	......	10.400	30.580	......	......	.143	......	37.048
1.090	.447	5.930	1.068	......	......	......	12.380	51.230	......	.....	(*)	......	19.138
.680	.930	5.290	.147	......	......	......	12.430	17.250	......	......	.112	......	44.133
1.980	1.550	7.075	.083	......	......	......	12.530	15.560	......	......	.185	......	42.344
2.535	1.073	5.930	.179	......	......	......	9.550	33.530	......	......	.059	......	32.806
.480	.921	3.914	.115	......	......	......	11.250	12.730	......	......	.216	......	48.822
2.263	4.270	2.970	.223	......	......	.....	.200	29.880	......	......	.065	......	41.867
.290	.122	6.719	.921	......	......	......	12.180	21.040	......	......	(*)	......	40.481
5.590	.609	1.368	1.074	......	......	......	8.940	37.380	......	......	.151	......	31.169
4.050	6.378	7.179	.102	......	......	......	.785	14.450	......	trace	.054	......	33.630
2.840		4.994	1.017	......	......	......	8.054	20.830	......	......	trace	......	37.945
12.036	3.677	3.583	.467	......	......	......	3.957	28.040	......	trace	.381	......	27.041
6.714	2.850	.835	.972	......	......	......	4.040	44.240	......	trace	.473	......	22.969
3.740	7.180	5.205	.179	......	......	......	8.788	17.010	......	.797	.237	......	29.418
2.490	4.828	2.454	.083	......	......	......	5.868	9.030	......	1.083	1.596	......	36.916
13.430	5.698	6.548	.211	......	......	......	6.681	22.230	......	trace	.185	......	27.136
.410	.317	4.299	.249	......	......	.....	5.600	61.730	......	......	.103	......	19.344
.540	.195	8.171	.345	......	......	......	9.750	31.900	......	......	.473	......	33.634
.643	.234	2.391	.535	......	......	......	7.900	44.180	......	......	.158	......	31.482
a trace	.248	9.656	.287	......	......	......	8.860	26.550	......	.....	*	......	38.750
a trace	.176	1.148	.280	......	......	......	8.920	32.504	......	......	*	......	39.880
a trace	.338	2.481	.073	......	......	......	6.152	72.280	......	.....	*	......	13.073

Table of iron ore

County.	Locality.	Kind of ore.	Specific gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of man-
Butler	Woodbury	Carbonate	3.026		70.200	
Ohio	Hartford	Limonite		30.480		[illegible]
	Livermore	do		60.180		[illegible]
Grayson	Big Caney and Little Clifty Creek	do		63.600		[illegible]
Edmondson	Nolin Ore Bank	do		60.900		[illegible]
	Nolin Iron Works	do		74.700		[illegible]
	W. B. Morris	do		62.120		[illegible]
	Nolin Iron Works	Carbonate	3.507		65.130	
Warren	Clay Lick Creek	Limonite		67.140		[illegible]
Butler	Alum Spring	Carbonate	3.490	7.190	65.960	
Muhlenburg	Hawes Ridge	Limonite.	2.571			[illegible]
	Old Furnace	do	.283			[illegible]
	Kincheloe's Bluff	do	3.460			[illegible]
	Turner's & Buckner's Old Iron Works	Carbonate	3.110		64.870	
	Williams's Landing	do	3.190		62.420	
	Battist Creek	do	2.940		64.900	
	Fordswell	do	2.924		74.460	
	Slate Bank	do	3.218		54.320	
	Slate Ore Bank	do	3.289		62.590	
	Greenville	do	2.520		85.000	[illegible]
	Hoskin's Muddy Creek	Limonite				[illegible]
Edmondson	B. Merideth	do		55.028		[illegible]
	Sycamore Creek	do		76.284		
	Nolin Furnace	do				[illegible]
	Beaver Dam Creek	do		52.926		[illegible]
	Near Nolin Furnace	do		27.340		
Muhlenburg	Airdrie Furnace	do		63.048		
	J. M. Hopes	do		60.492		[illegible]
	Do	do		46.866		
	Greenville	do		69.546		
	Airdrie Furnace	do		59.810		
Grayson	Near Nolin Furnace	do		57.830		
	Taylor's Ford Beaver Creek	do		44.528		
	J. H. Higdon's	Clay, iron, stone		6.536	60.466	
	West of Beaver Creek	do		42.761	19.59*	
Butler	John Hudson's	do		17.945	29.914	
	Knob Lick	do		17.313	22.583	
Muhlenburg	Airdrie Furnace	do	3.376	9.054	47.810	
	Buckner's Furnace	do		29.618	42.950	
	Jerry Hope's Bank	do		18.374	26.645	
Grayson	Rock Creek	Limonite		27.192		[illegible]
Butler	J. E. Taylor's	do		48.040		
	Stevens's Coal Mines	do		44.794		[illegible]
Ohio	Dooring's Bank	do		55.337		
	Do	do		56.972		
	Mrs. K. Inglehart's	do		18.676		

* Not estimated.

of Green River.

Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid.	Sulphur.	Potash.	Soda.	Combined water.	Insoluble silicates and silica.	Oxide of iron.	Carbonate of manganese.	Sulphurous acid.	Bituminous matter.	Percentage of iron.
2.550	7.040	1.510	.640	trace	.420	.010	......	7.650	9.920	1.600	......	......	39.450
trace	1.120	1.810	.640	......	.340	.060	8.280	47.370	......	......	......	......	27.640
trace	.730	4.850	.600	......	.400	.080	13.140	19.750	......	......	......	......	42.140
..270	1.220	2.360	.890	......	.250	......	12.020	19.150	......	......	......	......	44.540
trace	1.150	.650	.570	......	.300	.320	11.150	23.680	......	......	......	......	42.640
trace	.150	.450	.550	......	(*)	(*)	11.190	12.650	......	......	......	......	52.310
trace	.290	2.450	.430	......	.380	.420	13.250	20.550	......	......	0.060	......	43.500
1.950	8.450	.950	.360	0.100	.570	.050	......	9.170	7.980	1.830	.670	2.890	37.040
.270	.670	.800	.860	......	.370	......	11.160	17.950	......		......	......	47.020
5.900	6.030	......	2.640	......	.230	.060	.690	8.700	......	1.570	......	1.030	36.900
.050	.530	2.700	.310	......	.360	.120	11.200	35.900	48.700	......	......	......	34.100
.390	.250	2.520	2.650	......	.210	.030	11.500	19.300	62.200	......	......	......	43.560
.440	.200	1.870	.630	......	(*)	(*)	11.000	25.100	60.700	......	......	......	42.500
3.580	4.260	.670	.930	......	.230	.280	.900	16.250	4.390	1.090	......	1.400	34.180
3.650	7.410	.950	.100	......	.230	.120	1.570	15.270	3.380	2.490	......	2.420	32.520
3.250	6.570	.600	.350	......	.170	.520	.110	7.070	7.410	1.180	......	7.870	36.540
2.450	4.700	.700	.380	......	(*)	(*)	1.230	5.950	1.150	1.030	......	7.900	36.800
3.870	2.970	.500	.530	......	.080	......	1.910	21.940	6.750	2.680	......	4.440	31.170
2.670	4.690	1.870	a trace	......	.230	.120	1.030	8.190	14.790	1.420	......	2.400	40.260
......	1.150	.157	.350	......	.380	......	.460	7.950	......	......	......	3.140	......
trace	.615	1.000	1.591	......	.154	.106	11.300	16.980	67.340	......	6.800	......	47.159
trace	1.080	1.006	3.120	......	......	......	8.300	35.180	......	......	.133	......	35.519
180	.068	2.361	1.055	......	......	......	12.000	7.950	......	......	.151	......	53.399
1.180	.419	2.057	2.423	......	.201	.066	9.670	45.670	37.240	......	.544	......	26.039
.180	.425	4.792	.355	......	......	......	10.400	30.580	......	......	.143	......	37.048
1.090	.447	5.930	1.068	......	......	......	12.380	51.230	......	......	(*)	......	19.138
.680	.930	5.290	.147	......	......	......	12.430	17.250	......	......	.112	......	44.133
1.980	1.550	7.075	.083	......	......	......	12.530	15.560	......	......	.185	......	42.344
2.535	1.073	5.930	.179	......	......	......	9.550	33.530	......	......	.059	......	32.806
.480	.921	3.914	.115	......	......	......	11.250	12.730	......	......	.216	......	48.822
2.263	4.270	2.970	.223	......	......	......	.200	29.880	......	......	.065	......	41.867
.290	.122	6.719	.921	......	......	......	12.180	21.040	......	......	(*)	......	40.481
5.590	.609	1.368	1.074	......	......	......	8.940	37.380	......	......	.151	......	31.169
4.050	6.378	7.179	.102	......	......	......	.785	14.450	......	trace	.054	......	33.630
2.840		4.994	1.017	......	......	......	8.054	20.830	......	......	trace	......	37.945
2.036	3.677	3.583	.467	......	......	......	3.957	28.040	......	trace	.381	......	27.041
5.714	2.850	.835	.972	......	......	......	4.040	44.240	......	trace	.473	......	22.969
3.740	7.180	5.205	.179	......	......	......	8.788	17.010	......	.797	.237	......	29.418
2.490	4.828	2.454	.083	......	......	......	5.868	9.030	......	1.083	1.596	......	36.916
3.430	5.698	6.548	.211	......	......	......	6.681	22.230	......	trace	.185	......	27.136
.410	.817	4.299	.249	......	......	......	5.600	61.730	......	......	.103	......	19.344
.540	.195	8.171	.345	......	......	......	9.750	31.900	......	......	.473	......	33.634
.643	.234	2.391	.535	......	......	......	7.900	44.180	......	......	.158	......	31.482
trace	.248	9.656	.287	......	......	......	8.860	26.550	......	......	*	......	38.750
trace	.176	1.148	.280	......	......	......	8.920	32.504	......	......	*	......	39.880
trace	.338	2.481	.073	......	......	......	6.152	72.280	......	......	*	......	13.073

Table showing coals of Green River.

County.	Locality.	Thickness.	Specific gravity.	Hygroscopic moisture.	Valuable combustible matter.	Coke.	Total volatile matter.	Carbon in the coke.	Ash.	Percentage of sulphur.	Carbon.	Hydrogen.	Nitrogen and oxygen.	Remarks.
Davies	Wolf Hill	......	1.275	......	......	......	......	......	2.00	.300	77.891	5.422	14.387	
	Triplett's	......	1.328	6.70	36.00	57.30	42.70	51.30	6.00	2.090	71.019	5.022	15.069	
	Dean's Mine	......	1.337	5.12	34.72	60.16	39.84	51.44	8.72	3.513	......	......	......	
	Knottsville	......	1.285	6.20	41.90	51.90	48.10	47.40	4.50	3.743	......	......	......	From Duncan's bank.
McLean	Wrightsburg	......	Not est.	1.60	36.46	62.00	38.00	31.36	30.64	Not est.	......	......	......	Bituminous shale.
	......do	......	1.241	3.30	36.00	60.70	39.30	57.88	2.82	1.024	......	......	......	
Ohio	Livermore	......	1.272	5.50	41.20	53.30	46.70	48.90	4.40	1.750	71.618	5.377	16.455	Pitchner's coal.
	Hartford	......	1.311	4.70	37.90	57.40	42.60	52.02	5.38	3.054	74.510	5.332	12.504	Barrett's coal.
	Cromwell	......	1.272	5.60	38.30	56.10	43.90	53.60	2.50	1.704	75.219	5.177	14.900	Jackson's coal.
	Elm Lick	......	1.321	3.70	36.64	59.66	40.34	55.30	4.36	1.241	......	......	......	Martin's bank.
	Point Pleasant	3′ 9″	1.401	3.20	37.06	59.74	40.26	47.24	12.50	6.809	......	......	......	Henry Davis mine.
Muhlenburg	Owensborough Junction	16″	1.280	4.60	42.60	52.80	42.70	50.06	2.74	1.601	......	......	......	Lewisville and Stroud City mine.
	......do	3′ to 4″	1.309	3.36	37.90	58.74	41.26	52.74	6.00	2.686	......	......	......	Memphis Coal Company's mine.
	......do	......	1.313	5.40	35.90	58.70	41.30	53.60	5.10	2.219	......	......	......	
	......do	4′ 8″	1.235	5.40	34.20	60.40	39.60	54.20	6.20	3.136	......	......	......	Saint Louis mine.
	......do	16″	1.307	4.60	37.60	57.80	42.20	52.64	5.16	2.372	......	......	......	Saint Louis Mine Gas Company.
Grayson	Falls of Rough Creek	2′	1.343	6.50	30.04	63.46	36.54	55.54	7.92	1.972	......	......	......	South or Allen bank.
	Dismal Creek	......	1.305	4.70	31.40	63.90	36.10	52.20	11.70	1.945	......	......	......	Tar Lick coal.
	Miller's Fork of Bear Creek	......	1.395	4.14	30.52	65.34	34.66	50.08	15.26	3.565	......	......	......	Gravelly Lick coal.
	Calloway Creek	......	1.346	6.26	32.44	61.30	38.70	53.80	7.50	1.476	......	......	......	W. B. McGrew's.
	Huntington Fork of Rock Creek	......	1.378	3.50	33.40	63.10	36.90	47.50	15.60	2.041	......	......	......	Copperas bank.
	Pearson's Branch	......	1.364	3.60	35.80	60.60	39.40	49.40	11.20	3.158	......	......	......	L. Higdons' subconglomerate.
Butler	Hickory Camp Creek	......	1.291	7.20	31.40	61.40	38.60	56.90	4.50	.200	......	......	......	Tygert's coal-bank.
	Welch Creek	......	1.247	4.00	34.70	61.30	38.70	60.70	.60	.268	......	......	......	Pardon Sheldon's coal.
Edmondson	Bear Creek	......	1.429	1.20	39.00	59.80	40.20	45.46	14.34	8.685	......	......	......	Gross.
	Shoal Branch	......	1.336	3.66	35.14	61.20	38.80	54.26	6.94	2.706	......	......	......	Nolin coal.
	Tar Lick	......	1.335	4.06	33.24	62.70	37.30	51.70	11.00	1.670	......	......	......	
	Mill Branch of Beaver	......	1.437	4.06	32.00	63.94	36.06	50.84	13.10	4.938	......	......	......	Average sample.
	Dismal Creek	......	1.346	2.60	33.80	63.60	36.40	53.14	10.46	2.425	......	......	......	Knob Lick.

In order to get the most reliable information relative to the wealth and productions of the upper valley of the Green, I applied to Gen. James A. Dawson, of Munfordville, and in response received a communication from which the following is extracted:

"The country within the influence of, and which will be benefited by, the proposed extension of navigation on the Green and Barren Rivers, embraces the counties of Warren, Allen, Barren, Monroe, Metcalf, Green, Adair, and Edmondson, comprising an area of fully 5,000 square miles. This area contains a large part of the finest farming land in the State. It is pre-eminently the tobacco belt, in which is grown a larger quantity of that staple than in any other section of the Union, embracing all grades from the finest bright wrapper to the heaviest shipping leaf. It is in some respects a peculiar region, being, as it were, a valley on the summit of a plateau.

"Muldraugh's Hill, a spur from the Cumberland Mountains, extends to the Ohio River, near the mouth of Salt River, and rises to the height of 600 feet above the water level of the Ohio at the mouth of the Green, and has been not inaptly styled a range of hills with but one face. Upon the top of this hill, in Hardin and Marion Counties, stretches out southwardly, for the distance of more than 100 miles, a table land, on which is situated the Green River Valley, including the counties before mentioned, and the southern declivity being near the Cumberland River. This valley contains, developed and undeveloped, the elements of national wealth to an almost incalculable amount.

"It is now, though not half developed, a very fine farming country. I have been at some pains to gather data, and, though the past year, 1879, was very far from being an average in the yield of farm products, it may be safely stated that in the counties aforesaid there were gathered and fatted, as the crop for the year, the following, in round numbers, viz, of tobacco, 20,000,000 pounds; of hogs, 135,000 head; of hay, 25,000 tons; of corn, 10,000,000 bushels; of wheat, 1,000,000 bushels; besides, oats, rye, barley, and potatoes in large quantities, and fruits of all grades adapted to the climate in the greatest abundance. Almost the entire valley is admirably adapted to grazing purposes, blue grass being indigenous to most of it, and orchard and other grasses, and clover growing very finely on the whole tract of country. At the present time the yield of cattle is by no means inconsiderable, and there is no section of the Union better suited for the raising of sheep, horses, and mules. Moreover, there are immense forests of superior timber and vast beds of the best iron ore, which only need the facilities of cheap transportation to insure their development. Many years ago there were two large furnaces and a forge profitably operated in Hart County and one in Edmondson County, and there are beds of the finest quality of iron ore in said counties and in Grayson County sufficient to supply the United States for the next century. The opening of arteries of cheap transportation in other sections of the country compelled the abandonment of these manufactories of iron, but if Green River be made reliable as an outlet to market at rates as low as elsewhere, these furnaces will again doubtless be soon in blast."

An account of Rough Creek, by Mr. A. B. Baird, has been kindly contributed to this report, and from its authorship, as well as the much valuable information it contains, is well fitted to constitute a portion of any general treatise on the Green River and its resources. Mr. Baird says:

"Rough Creek rises out of what is known as Big Spring, at the corner of the counties of Meade, Hardin, and Breckinridge; all of these counties corner in said spring. The creek that issues from the spring is soon joined by other streams fed by springs, and within a very few miles is large enough to turn a mill most of the year. The country around the head of this fork (the south fork) is an underdrain country for the most part, and of limestone formation. From the mill already alluded to, as the creek flows on and is joined by other tributaries, other mills have been built. The largest tributary is Big Clifty, from the south.

"The general course of Rough Creek is west. After a course by the devious winding of 30 miles it is joined by the North Fork, which is somewhat smaller than the South Fork. The South fork forms, first, the dividing line between Breckinridge and Hardin Counties; then between the former and Grayson County. At the junction of the two forks the stream has increased to a width of 100 to 220 feet. This point, the junction, is 15 miles above the Great Falls, the site of Green's Mill, and the slackwater from Green's Dam extends up to and above the forks. Between the forks and Green's Mill it receives a large tributary, Rock Lick, from the north. The water-power at Green's is as fine as any in the West; grinding, sawing, carding, spinning, and weaving are all done at this point, and the stream is spanned by an iron bridge, recently constructed by the counties of Breckinridge and Grayson.

"After leaving Green's Mill, the first tributary of much size is Pond Run, from the north, which is the dividing line between Breckinridge and Ohio Counties, and nearly opposite is Short Creek, from the south. This creek is only 2 miles long; comes from the ground a full-fledged creek, that runs a mill most of the year, which is only 100 or 200 yards from its source, and another mill is on the same creek, before its junction with Rough Creek.

"Passing on down the stream, the next tributaries are Brown's Creek and Mistaken from the south and Rosson's Fork from the north. Near this place is Hite's Fall, a beautiful perpendicular fall of 4 feet. At this point the formation changes from limestone to a mixture of sandstone, and a few miles below the limestone is nearly entirely wanting.

"A few miles below these falls is the mouth of Caney, the largest and most important tributary of Rough Creek. It is from the south and has been navigated by flatboats and rafts for more than 20 miles. A short distance below Caney is Huff Creek from the north, and 3 or 4 miles still lower down it receives Adams's Fork, the second tributary in size and importance. It is navigable for rafts for a number or miles. This tributary is from the north. Below this 4 or 5 miles is Hines's Mill, on Rough Creek, where there is a large custom mill, with sawing and grinding, and carding, &c. This point is 12 miles by land from Hartford, and the point where the road from that place to Fordsville crosses the creek.

"Descending the creek we have from the north, Hedges, Storer, and Bear Runs, and on the south, Hall's Creek, Morrison's, and Mill Run, which brings us down to Hartford, the county seat of Ohio County; Rough Creek being wholly in the county of Ohio after passing the mouth of Brown's Creek. At Hartford there is a fine custom mill for grinding corn and wheat, carding, spinning, weaving, &c., and the creek is spanned by a bridge of wood, shortly to be superseded by an iron one.

"From this place to the intersection of Green River is 28 miles by the creek, and it has No Creek, Barnett's Creek, and Sandy from the north; Bevis Lick, Walton's Muddy, and Grassy from the south.

"A stock company built a lock on the creek 8 miles above the mouth shortly after the war, that gave slackwater to Hartford, and numerous steamers ran in the creek, making regular trips and doing a large business, and one that was profitable alike to the steamers and the shippers. These steamers were from 100 to 125 feet long, and during the whole time navigation was kept up not one single accident occurred. But when Green River was transferred to a company the tolls were made so high that the boats were all compelled to leave the creek.

"The steamers having left, the lock was not worth attending to; was abandoned by the company, and the work went down.

"Rough Creek is as large at Green's Mill as at Hartford, and even above the falls to the forks (15 miles) there is no perceptible difference in width. In summer and fall as much water passes at Green's Mill as at Hartford, as shown by the number of square inches in the water let to the mills at these points. I am fortified in this statement by the experience of Joseph P. Hunter, an experienced millwright, who has rebuilt the mills at both the points contrasted.

"As to the probable number of locks that would be required to slackwater it to the falls at Green's Mill, an approximation is all that can now be stated. A survey only can determine the number and height of the locks and dams. The instrumental survey of the 28 miles from Hartford to Green River showed a fall of 17 feet; 4 feet of this was overcome by the slackwater from the river.

"I would propose as the location of locks as follows: No. 1 at or near the site of the company's old lock, 8 miles from the mouth; No. 2 at Hartford; No. 3 at some point say 15 miles above Hartford, by the stream; No. 4 at Hines's Mill; and No. 5 at Hite's Falls. This work would give slackwater to the Great Falls at Green's Mill, 103 miles by the creek from its mouth.

"The creek is flanked on both sides by a forest, comprising all the varieties of oak, with poplar, black and white walnut, hickory, gum, cherry, persimmon, birch, and elm, with an undergrowth of dogwood, red-bud, pawpaw, and spice brush. Much of the poplar and oak have been run as rafts to Evansville and other markets, or made into staves and carried in flatboats to New Orleans, but there is a vast and almost inexhaustible quantity yet on or contiguous to the creek. There are also many other kinds of timber than those named that are very valuable, such as chestnut, maple, locust, and catalpa. Around the falls there are vast forests of chestnut-oak, which produces the finest tanbark known to tanners.

"It is not known certainly that minerals can be found in the limestone formation, but near where this changes to sandstone lead has been found, and considerable mining done for it; but from the want of experience and capital on the part of those engaged in it, and for want of reliable and cheap transportation, operations have been suspended. At other points on the creek, between Hines's Mill and Hartford, lead has been found.

"As soon as the creek enters the sandstone formation it is flanked on each side by beds of bituminous coal, from 2 to 6 feet thick; these veins, for want of reliable navigation, have been operated only for neighborhood purposes. This coal-field extends to the mouth of the creek, a distance of 80 miles by the creek In this section of the creek iron ore, in vast quantities, is found; at one place especially, some eight miles above Hartford, is a deposit that has been called 'Iron Mountain' from the vast deposit of that ore at that point. Along the creek, or contiguous to it, are many mineral

prings, the most celebrated of which is White Sulphur, 2 miles from Hines's Mill; salt as been found at many places, and many wells were worked in the primitive days of e State.

"An air line from the falls at Green's Mill to the mouth of the creek is about 45 iles. The nearest points of the creek to the Ohio River are from Green's Mill to lovorport, 24 miles, and from Hartford to Owensborough, 27 miles. The distance from reen's Mill to the Paducah and Elizabethtown Railroad at Caneyville is 15 miles, and om Hartford to same road is 5 miles. The slackwatering of Rough Creek will make a competitor for the trade of the country to an equidistant point from it to the Ohio iver and the railroad, and will give the creek a monopoly in carrying minerals. hus the slackwater of Rough Creek will have the trade of more than 1,000 square iles of good average farming land of this section of the State, not over one-half of hich is now cultivated. This is in the heart of the best tobacco belt in the State, nd produces corn, wheat, oats, and the very best hay, besides all of the smaller garen products. I would mention also that rough Creek is considered one of the best treams for fish in the State. A large number of the improved breeds have been placed i it, and they are found to be prospering finely.

"Rough Creek runs, by its meanderings, through Ohio County about 80 miles, dividig the county in proportion of three-sevenths on the north and four-sevenths on the outh. The county is prospering and increasing in population as no other county of he State that has no large towns or cities in it. The last return of votes showed 4,200. 'ruits of all kinds flourish and do well, and besides the large timber I have mentioned failed to mention hoop poles; they are abundant and inexhaustible, as the same round can be cut over every three or four years. Horses, cattle, hogs, sheep, and iules are healthy. Land is cheap along the creek, which would, by the slackwaterng, be trebled in a few years. *Rough Creek is the largest creek in the world.*—A. B. BAIRD."

The general characters of Green and Barren Rivers differ in several respects very trikingly from those of the Kentucky River, as observed in the course of the survey f that stream in the autumn of 1878. The Kentucky River contains nothing that leserves the name of an island, from its source to its mouth. The Green and the Barren are full of islands, and they seem to increase in size and frequency as you asend the streams. The Kentucky River is mainly fed by copious surface streams, and ias notably few large springs discharging into it. The Green River, especially the ipper portion of it, has but a small number of surface tributaries, while in great gushng springs it seems to excel. These springs occur almost in sight of one another along he margin of the upper river, and are of such capacity as frequently to be used for unning mills. They constitute the principal feeders of the river. This phenomenon uggests the possibility of difficulty in maintaining pools, since it is not improbable hat in some cases at least the water comes by underground passages from the river ibove.

TABLE A.—*Existing and proposed dams on Green and Big Barren Rivers, Kentucky.*

River.	Number of dam.	Distance from Ohio River.	Locality.	When built.	Lock. Lift.	Lock. Length.	Lock. Width.	Dam. Length.	Dam. Width of base.	Dam. Greatest height.	Surface of upper pool, above low-water in Ohio River.	Surface of low-water in river above low-water in Ohio River.	Length of pool.
		Miles.			*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Miles.*
Green	1	8.25	Spottsville	1841.	14.5	160	36	600	46	20	14.5	....	51.75
	2	60.00	Bumsey	1837.	14.5	160	36	600	46	......	29.0	....	43.50
	3	103.50	Rochester	1838.	15.5	160	36	260	60	......	44.5	....	41.50
	4	145.00	Woodbury	1840.	16.5	160	36	270	......	24	61.0	....	Barren..15.00 Green..20.25
		145.33	Mouth of Big Barren										
	5	165.25	Floyd's Landing	Proposed	13.5	160	36	170	70	21	74.5	61.0	16.45
	6	181.70	Buffalo Creek	do	13.5	160	36	140	70	22	88.0	68.9	11.03
	7	192.73	Mammoth Cave	do	12.0	160	36	480	64	22	100.0	85.1	10.11
	8	202.84	Saunder's Ripple	do	12.0	160	36	150	64	21	112.0	97.0	9.00
	9	211.84	Hazelip Bend	do	12.0	160	36	150	64	20	124.0	106.7	7.68
	10	219.52	Mumfordville	do	12.0	160	36	160	64	21	136.0	119.5	10.47
	11	229.99	Burnt Bridge	do	12.0	160	36	150	64	22	148.0	132.6	9.48
	12	239.47	Lynn Camp Creek	do	12.0	160	36	180	64	20	160.0	145.3	10.25
		242.72	Little Barren River									149.1	
		256.42	Abner's Ferry									170.9	
		260.00	Willis Ferry									179.7	
		266.77	Russell's Creek									188.6	
		269.27	Greensburg									197.8	
Big Barren		145.33	Mouth of Big Barren										
	1	160.00	Near Greencastle	1841.	15.5	160	36	300	70	20	76.5	....	15.00
	2	175.00	Bowling Green	Proposed	12.0	160	36	250	64	20	88.5	....	14.67
	3	189.67	Drake's Creek	do	12.0	160	36	100	64	22	100.5	84.7	9.00
		208.77	Bay's Fork									112.5	
		224.07	Big Difficult Creek									130.9	
		230.37	Beaver Creek									150.2	
		234.77	Peter's Creek									163.2	
		235.17	End of survey									164.5	

(Those on Pond River and Rough Creek are copied from report of H. D. Taylor, December 8, 1836.)

Tributary.	Locality.	Distance from the Ohio River.	Distance from the Green River.	Elevation of low-water above low-water in Ohio River.	Elevation of low-water above low-water in Green River.	Remarks.
					In pool No. 1.	
Pond River	Mouth of Pond River	54.70	0.0	14.50	0.0	
	Morgan's Mill		18.18		17.063	
	McNeary's Ford		27.63		19.341	
	Bard or Guthrie's Ford		47.00		36.232	
	Long Creek		61.06		49.530	
	Hopkinsville and Greenville Bridge		64.56		55.098	
					In pool No. 2.	
Rough Creek	Mouth of Rough Creek	71.50	0.0	20.00	0.0	
	Hartford		28.00		17.056	
	Heckley's Ford		45.00		30.838	
	Comb of Taylor's Dam		55.25		44.292	
	Comb of Landrum's Dam		71.75		56.557	Total fall of dam and ripple, 7.908.
	Comb of Green's Dam		81.25		78.509	Total fall of dam and ripple, 5.320.
	Frank's Old Mill		104.50		89.436	Total fall of dam and ripple, 13.354.
	Lampton's Old Mill		114.25		101.027	
					In pool No. 4.	
Nolin River	Mouth of Nolin River	178.16	0.0	66.00		
	Hardin's Mills		18.6		5.0	
	Rock Creek		23.4		43.9	
	Bacon Creek		39.6			
	Dawsay's Mill		40.6			
					In pool No. 4.	
Little Barren	Mouth of Little Barren	242.72	0.0	149.1	88.1	
	Mitchell's Ferry		2.4		94.8	
	End of survey		4.2		100.9	

TABLE C.—*Estimated cost of the proposed extension of slackwater on Green River, Kentucky, with timber dams.*

Number of lock	5			6			7			8		
Locality	Floyd's Landing.			Buffalo Creek.			Mammoth Cave.			Saunder's Ripple.		
	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.
Excavation below water, rock, cubic yards	2, 698	$2 00	$5, 396	2, 394	$2 00	$4 788	1, 300	$1 50	$1, 950	1, 157	$2 00	$2, 314
Excavation below water, earth, cubic yards	710	50	355	656	50	328	5, 600	40	2, 240	578	50	289
Excavation above water, rock, cubic yards	720	75	540	400	75	300	350	75	263	200	75	150
Excavation above water, earth, cubic yards	2, 800	17	476	2, 380	17	405	8, 000	17	1, 360	2, 200	17	374
Timber in locks, linear feet	10, 788	09	971	10, 788	09	971	10, 788	09	971	10, 788	09	971
Timber in locks, feet, board measure	141, 626	025	3, 541	147, 366	025	3, 684	133, 016	025	3, 325	130, 146	025	3, 254
Timber in dams, linear feet	38, 250	07	2, 678	35, 700	07	2, 499	93, 600	07	6, 552	29, 250	07	2, 048
Timber in dams, feet, board measure	105, 400	02	2, 108	86, 800	02	1, 736	321, 600	02	6, 432	100, 500	02	2, 010
Timber in guide walls, linear feet	24, 000	07	1, 680	28, 800	07	2, 016	22, 800	07	1, 596	23, 200	07	1, 624
Masonry in locks, ashlar, cubic yards	3, 320	8 00	26, 560	3, 494	8 00	27, 952	3, 059	8 00	24, 472	2, 972	8 00	23, 776
Masonry in locks, rubble, cubic yards	2, 489	6 00	14, 934	2, 695	6 00	16, 170	2, 180	6 00	13, 080	2, 077	6 00	12, 462
Masonry in abutments, rubble, cubic yards	666	4 00	2, 664	868	4 00	3, 472	....	....	....	868	4 00	3, 472
Paving, cubic yards	800	1 50	1, 200	800	1 50	1, 200	200	1 50	300	800	1 50	1, 200
Iron in locks, wrought, pounds	14, 800	06	888	15, 100	06	906	14, 350	06	861	14, 200	06	852
Iron in locks, cast, pounds	9, 200	04	368	9, 200	04	368	9, 200	04	368	9, 200	04	368
Iron in dams, wrought, pounds	46, 126	06	2, 768	39, 780	06	2, 387	110, 712	06	6, 643	34, 538	06	2, 072
Iron in guide walls, wrought, pounds	7, 600	06	456	8, 400	06	504	8, 000	06	480	8, 400	06	504
Rock filling in dams, cubic yards	5, 383	50	2, 692	5, 030	50	2, 515	15, 000	50	7, 500	4, 750	50	2, 375
Rock filling in guide walls, cubic yards	1, 440	50	720	1, 760	50	880	1, 440	50	720	1, 760	50	880
Gravel backing, cubic yards	4, 500	40	1, 800	3, 000	40	1, 200	8, 000	40	3, 200	3, 500	40	1, 400
Embankments	650	15	98	650	15	98	400	15	60	650	15	98
			72, 893			74, 379			82, 373			62, 493
Clearing banks and bed of river, per pool	....	....	4, 950	....	....	3, 300	....	....	3, 000	....	....	2, 700
Incidentals and contingencies, 15 per cent	....	....	1, 676	....	....	11, 651	....	....	12, 800	....	....	9, 779
Total cost at each site	....	....	89, 519	....	....	89, 330	....	....	98, 173	....	....	74, 972

TABLE C.—*Estimated cost of the proposed extension of slackwater on Green River, &c.*—Continued.

Number of lock	9.			10.			11.			12.			Total cost on Green River.
Locality	Hazelip's Bend.			Munfordville.			Burnt Bridge.			Lynn Camp Creek.			
	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	
Excavation below water, rock, cubic yards	670	$2 00	$1, 340	904	$2 00	$1, 808	1, 720	$2 00	$3, 440	1, 500	$2 00	$3, 000	
Excavation below water, earth, cubic yards	1, 440	50	720	768	50	384	....	....	....	580	40	232	
Excavation above water, rock, cubic yards	770	75	578	560	75	420	576	75	432	1, 100	75	825	
Excavation above water, earth, cubic yards	2, 240	17	381	2, 000	17	340	2, 200	17	374	2, 600	17	442	
Timber in locks, linear feet	10, 788	09	971	10, 788	09	971	10, 788	09	971	10, 788	09	971	
Timber in locks, feet, board measure	130, 146	025	3, 254	130, 146	025	3, 254	133, 016	025	3, 325	127, 307	025	3, 183	
Timber in dams, linear feet	31, 200	07	2, 184	33, 280	07	2, 330	29, 250	07	2, 048	35, 100	07	2, 457	
Timber in dams, feet, board measure	100, 500	02	2, 010	107. 200	02	2, 144	100, 500	02	2, 010	120, 600	02	2, 412	
Timber in guide walls, linear feet	25, 200	07	1, 764	24, 000	07	1, 680	25, 200	07	1, 764	21, 600	07	1, 512	
Masonry in locks, ashlar, cubic yards	2, 972	8 00	23, 776	2, 972	8 00	23, 776	3, 059	8 00	24, 472	2, 798	8 00	22, 384	
Masonry in locks, rubble, cubic yards	2, 077	6 00	12, 462	2, 077	6 00	12, 462	2, 180	6 00	13, 080	1, 871	6 00	11, 226	
Masonry in abutments, rubble, cubic yards	868	4 00	3, 472	868	4 00	3, 472	1, 000	4 00	4, 000	868	4 00	3, 472	
Paving, cubic yards	800	1 50	1, 200	800	1 50	1, 200	800	1 50	1, 200	800	1 50	1, 200	
Iron in locks, wrought, pounds	14, 200	06	852	14, 200	06	852	14, 350	06	861	13, 900	06	834	
Iron in locks, cast, pounds	9, 200	04	368	9, 200	04	368	9, 200	04	368	9, 200	04	368	
Iron in dams, wrought, pounds	35, 220	06	2, 113	37, 568	06	2, 254	34, 538	06	2, 071	41, 460	06	2, 488	
Iron in guide walls, wrought, pounds	8, 800	06	528	8, 000	06	480	8, 800	06	528	7, 200	06	432	
Rock filling in dams, cubic yards	5, 067	50	2, 534	4, 646	50	2, 323	4, 750	50	2, 375	5, 700	50	2, 850	
Rock filling in guide walls, cubic yards	1, 680	50	840	1, 600	50	800	1, 680	50	840	1, 440	50	720	
Gravel backing, cubic yards	3, 000	40	1, 200	3, 500	40	1, 400	3, 700	40	1, 480	4, 500	30	1, 350	
Embankments	300	15	45	600	15	90	600	15	90	600	15	90	
			62, 592			62, 808			65, 730			62, 448	
Clearing banks and bed of river, per pool	....	....	2, 300	....	....	3, 100	....	....	2, 800	....	....	2, 700	
Incidentals and contingencies, 15 per cent	....	....	9, 734	....	....	9, 886	....	....	10, 280	....	....	9, 772	
Total cost at each site	....	....	74, 626	....	....	75, 794	....	....	78, 810	....	....	74, 920	$656, 144

TABLE D.—*Estimated cost of the proposed extension of slackwater in the Big Barren River, Kentucky.*

Number of lock	2.			3.			Total cost on Big Barren River.
Locality	Bowling Green.			Drake's Creek.			
	Number.	Price.	Amount.	Number.	Price.	Amount.	
Excavation below water, rock, cubic yards	4, 472	$2 25	$10, 062	1, 965	$2 00	$3, 930	
Excavation below water, earth, cubic yards	....	....	....	....	....	....	
Excavation above water, rock, cubic yards	4, 312	75	3, 234	1, 660	75	1, 245	
Excavation above water, earth, cubic yards	2, 074	17	354	2, 200	17	374	
Timber in locks, linear feet	10, 788	09	971	10, 788	09	971	
Timber in locks, feet, board measure	141, 626	025	3, 541	127, 632	025	3, 191	
Timber in dams, linear feet	48, 750	07	3, 413	28, 600	07	2, 002	
Timber in dams, feet, board measure	167, 500	02	3, 350	100, 500	02	2, 010	
Timber in guide walls, linear feet	18, 200	07	1, 274	25, 200	07	1, 764	
Masonry in locks, ashlar, cubic yards	3, 320	8 00	26, 560	2, 972	8 00	23, 776	
Masonry in locks, rubble, cubic yards	2, 489	6 00	14, 934	2, 077	6 00	12, 462	
Masonry in abutments, rubble, cubic yards	666	4 00	2, 664	1, 481	4 00	5, 924	
Paving, cubic yards	800	1 50	1, 200	600	1 50	900	
Iron in locks, wrought, pounds	14, 800	06	888	14, 200	06	852	
Iron in locks, cast, pounds	9, 200	04	368	9, 200	04	368	
Iron in dams, wrought, pounds	57, 898	06	3, 474	34, 310	06	2, 059	
Iron in guide walls, wrought, pounds	7, 092	06	426	8, 326	06	500	
Rock filling in dams, cubic yards	3, 000	50	1, 500	4, 488	50	2, 244	
Rock filling in guide walls, cubic yards	1, 440	50	720	1, 600	50	800	
Gravel backing, cubic yards	6, 000	50	3, 000	2, 000	40	800	
Embankments	300	15	45	650	15	98	
			81, 978			66, 270	
Clearing banks and bed of river, per pool	....	....	4, 410	....	....	2, 700	
Incidentals and contingencies	....	....	12, 958	....	....	10, 345	
Total cost at each site	....	....	99, 346	....	....	79, 315	$178, 6[illegible]

TABLE [illegible].—*Estimated cost of masonry dams on Green River at sites having rock bottoms.*

Number of dam	6.			7.			8.			9.			10.			11.			Total cost with two timber dams and six masonry dams.
Locality	Buffalo Creek.			Mammoth Cave.			Saunder's Ripple.			Hazelip's Bend.			Mumfordville.			Burnt Bridge.			
	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	Number.	Price.	Amount.	
Length of dam in feet	140			480			150			150			160			150			
Greatest height in feet	29			27			22			22. 5			22. 5			23			
Average	26			25			21			22			22			21			
Thickness	13. 5			13. 5			12			12			12			12			
Excavation below water, rock, cubic yards	140	$2 00	$280	125	$2 00	$250	50	$2 00	$100	50	$2 00	$100	60	$2 00	$120	50	$2 00	$100	
Excavation below water, earth, cubic yards	350	50	175	1, 000	50	500	150	50	75	150	50	75	160	50	80	150	50	75	
Excavation above water, rock, cubic yards	50	75	38	50	75	38	50	75	38	50	75	38	50	75	38	50	75	38	
Excavation above water, earth, cubic yards				1, 250	17	213													
Masonry, cubic yards	1, 820	6 00	10, 920	6, 000	6 00	36, 000	1, 400	6 00	8, 400	1, 466	6 00	8, 796	1, 564	6 00	9, 384	1, 400	6 00	8, 400	
Iron, pounds	1, 050	06	63	3, 600	06	216	1, 125	06	68	1, 125	06	68	1, 200	06	72	1, 125	06	68	
Coffer dam			3, 975			12, 832			3, 500			3, 250			2, 672			3, 500	
Common amount taken from Table C			67, 392			55, 046			55, 288			54, 851			55, 457			58, 545	
			82, 843			105, 095			67, 469			67, 178			67, 823			70, 726	
Clearing river banks and bottom, per foot			3, 300			3, 000			2, 700			2, 300			3, 100			2, 800	
Incidentals and contingencies, 15 per cent			12, 922			16, 214			10, 525			10, 421			10, 639			11, 029	
Total cost at each site			99, 065			124, 309			80, 694			79, 899			81, 562			84, 555	
Total cost of 6 locks, with masonry dams																		550, 084	$714, 523

In the execution of this work I was principally aided by Hugh R. Ayres, B. R. Turner, and F. M. Pryor. To these gentlemen, but especially to Mr. Ayres, my thanks are due for an unusually faithful performance of the several duties committed to their charge.

Very respectfully submitted.

R. H. FITZHUGH,
Assistant Engineer.

Col. WM. E. MERRILL,
Major, Corps of Engineers, U. S. A.

APPENDIX A.

AN ACT to incorporate the Green and Barren River Navigation Company.

Whereas the Green and Barren River line of navigation has always been a charge upon the State, and is now largely in debt and without prospect of any better condition; and whereas it is of great importance to the country to keep said line in working order and at the same time to avoid any public expense if possible, and believing that object can be accomplished by letting it to an incorporated company: Therefore,

Be it enacted by the general assembly of the commonwealth of Kentucky:

§ 1. That J. A. Robinson, J. V. Sprowle, W. S. Vanmeter, C. J. Vanmeter, E. B Seeley, H. C. Murrell, Wm. Brown, D. C. Turner, C. J. Smallhouse, and their associates and successors, be, and they are hereby, created a body corporate with the name and style of the Green and Barren River Navigation Company, and shall have perpetual succession during the term of thirty years, and in that name may sue and be sued, make contracts, and transact all their legitimate business as a corporation; may use and change their common seal; and make suitable by-laws for the regulation of the affairs of the company and to regulate their elections to fill offices, vacancies, and in all things not inconsistent with the laws of the land.

§ 2. That the said Green and Barren River line of navigation and their tributaries, together with the grounds, houses, water-works, rents, profits, tools, machinery, implements, and appurtenances, and all the franchises thereunto belonging or appertaining, be, and the same are hereby, loaned and conveyed unto the corporators named in the first section of this act, and to their associates, successors, executors, heirs and assigns, for and during the term of thirty years from and after the time they get possession thereof; and it shall be the duty of the governor of this commonwealth to cause possession thereof to be delivered unto them as soon after the passage of this act as they or any of them who may choose to accept may give notice of readiness to receive it, upon their complying with all the conditions precedent herein provided.

§ 3. The business of the company may be to use and suffer to be used said line of navigation for all purposes of navigation, and also the water-power, property, rights, appurtenances, and all the franchises thereunto belonging, as they may direct, not inconsistent with the purposes of said line, as expressed by law; and as an auxiliary to said business, and to facilitate commerce and trade, and to develop the resources of wealth along said line, it may also be their business to open and work coal mines and other mines and to deal in the products thereof, as also in the products of the country and other things as well as in the work of machinery and navigation on said line. They may also lease, buy, sell, hold, and otherwise acquire and dispose of any real and personal estate, by any manner not prohibited by law, the same as a natural person, and may do all necessary or advantageous acts in the same way, in the transaction of their business, not inconsistent with the constitution of this State or of the United States.

§ 4. It shall be the business and duty of said company to use due diligence in keeping up said line of navigation in good repair, and to return it and all its appurtenances at the expiration of the lease, in good condition, as at present, or unless prevented from so doing by unavoidable causes, and to hold the State harmless in the premises, and to pass and permit all boats, crafts, and other things to navigate said rivers, according to certain specified rates herein prescribed as tolls, which shall inure to said company.

§ 5. [Organization, &c., of company] * * * and a prior lien is hereby retained by the commonwealth against all the property, rights, and franchises of said company, as security to said commonwealth for the faithful performance of all the duties herein imposed upon said company; and no individual of said company shall be bound for said company beyond the interest he may have therein.

§ 6. All tolls shall inure to the company, and the rate of toll on passenger and freight steamboats, and other boats carrying freight, other than coal or stone, shall be regulated by their full hull or deck tonnage, according to the custom-house rules as to the management of tonnage: *Provided*, That the rate of toll for such boats passing such locks shall not exceed per ton, measured as aforesaid, fifty cents at the first lower lock, and thirty cents at the second, and twenty cents at the third, and ten cents each at the

two other upper locks, and same for returning; and for each passenger, and for all other boats, barges, skiffs, and other water-crafts, loaded and empty, including rafts and other things passing said rivers, they may establish tolls from time to time not exceeding the present rates established by the board of internal improvement as applicable to the Kentucky, Green, and Barren River lines of navigation at this time.

§ 7. [Transfers of interest, &c.]

§ 8. [Liabilities for damages.]

§ 9. [Steamboats, rafts, &c., shall obey company's rules.]

§ 10. [Penalty for willful injury of works.]

§ 11. It shall be the duty of the company, or such of them as may choose to accept the provisions of this charter, together with their associates whom they may choose to associate with them, to execute their bond to the commonwealth of Kentucky, with security, the solvency of which to be approved by the governor of said commonwealth, and be attested by him under the seal of his office, which bond shall be in duplicate, one copy to be retained by the State and the other by the company. The conditions of the bond shall be as follows: "In consideration of the undisturbed possession of the Green and Barren River line of navigation and its tributaries, together with its grounds, houses, water-powers, rents, profits, tools, machinery, implements, appurtenances, and all its franchises thereunto belonging or appertaining, now to be delivered to us, the undersigned, to hold for thirty years, under an act of the legislature incorporating the Green and Barren River Navigation Company; we accept the same, and as a company aforesaid, are bound hereby in the penal sum of five hundred thousand dollars, to perform the duties and obligations imposed by said act of the legislature; and to return the same in good order, as set out in said act, subject to the conditions therein expressed. Given under our hands and corporate seal of said company this —— day of ———, 18—." Which bond, being executed by the parties aforesaid, and approved as aforesaid, and attested by the governor, shall entitle the company and their associates to all the rights conferred by this act: *Provided, however,* That said company may associate others with them before or after the execution of said bond: *And provided further,* That the commonwealth shall have a lien upon all the property of said company to secure a compliance with the stipulations of said bond.

§ 12. This act to be in force from its passage.

Approved March 9, 1868.

AN ACT to amend and explain an act entitled "An act to incorporate the Green and Barren River Navigation Company," approved March 9, 1868.

Whereas an act entitled "An act to incorporate the Green and Barren River Navigation Company," approved March 9, 1868, authorizing said company to collect certain tolls from boats and other things navigating said rivers according to the rates established by the board of internal improvement, as then applicable to the Kentucky, Green, and Barren River lines of navigation, and whereas the rates so established as applicable to the Kentucky River, are not deemed applicable to Green and Barren Rivers, and are misleading; and whereas complaints have been made that said company have violated the spirit of their charter by giving it a wrong construction to the prejudice of the public, and in making changes not contemplated therein, and that are not authorized by law; and whereas it is clear that said company have vested rights under their said charter that cannot be impaired, but which may be confined to their just and legitimate limits: Therefore to explain and limit the rights of said company in the protection of the public, while at the same time the vested rights of the said company must be respected, it is now enacted by the general assembly of the commonwealth of Kentucky:

SEC. 1. That the charges herein prescribed and limited may be charged by said company against boats, barges, and things navigating said line of navigation, and no greater charges therefor shall be made.

SEC. 2. That the rate of tolls authorized by said act to be charged against boats, according to the tonnage rule or principle, shall not apply to boats or things plying only between the dams; but all boats, barges, and other crafts plying only between the dams on slackwater in said line of navigation shall not be required to pay any other or greater tolls than such as were established by the board of internal improvement, and that were in force at the time of the passage of said act, and that were applicable alone to the Green and Barren River line of navigation, except as herein limited.

SEC. 3. No boat used exclusively in towing shall be required to pay tolls according to the rules of tonnage as claimed under said act. Such boats, in passing the locks and dams, shall only be required to pay two dollars therefor at each lock to said company.

SEC. 4. The charge of two dollars lockage claimed under said act shall not be paid on any raft of timber passing said locks and dams, but the charges shall be as fixed by the board of internal improvement, and it is as follows: for rafts fifteen feet wide

and under, three cents per lineal foot at each lock; over fifteen feet and under twenty feet wide, five cents per lineal foot at each lock; rafts twenty feet wide and under thirty feet wide, six cents per lineal foot at each lock; rafts thirty feet wide and under thirty-six feet wide, seven cents per lineal foot at each lock.

SEC. 5. No flat-boat or barge starting from above the influence of slackwater shall be required to pay any tolls except for passing through a lock, and that shall not exceed the rates prescribed by law.

SEC. 6. No flat-boat or barge starting within the influence of slackwater shall be required to pay exceeding two dollars lockage and three cents per lineal foot of each boat or barge at each lock; and the two-dollar lockage herein authorized by this section shall not be chargeable unless the boat or barge actually passes through the lock.

SEC. 7. No flat-boat or barge loaded with coal or stone or sawed lumber shall be required to pay exceeding two dollars lockage and six cents per lineal foot for such boat or barge at each lock; but the two dollars lockage shall not be chargeable unless the boat or barge actually passes through the lock.

SEC. 8. This act shall take effect and be in force from and after its passage.

Approved March 15, 1876.

Acts of 1878, page 513, chapter 432.

Be it enacted by the general assembly of the commonwealth of Kentucky:

SEC. 1. That section 5 of an act entitled "An act to amend and explain an act entitled 'An act to incorporate the Green and Barren River Navigation Company, approved March 9, 1868,' approved March 15, 1876," be amended by inserting after the word barge the following: "or rafts of logs or timber of any kind."

SEC. 2. That section 6 of said act be amended by adding after the word "barge" whenever it occurs in said section the following: "or rafts of logs or other timber."

SEC. 3. This act shall be in effect from and after its passage.

Approved March 14, 1878.

APPENDIX D.

COMMERCIAL STATISTICS.

GREEN AND BARREN RIVER NAVIGATION COMPANY,
Bowling Green, Ky., December 26, 1879.

The exports of Green River will approximate as below stated, the estimate being taken from the books of our company:

Hogsheads of tobacco	6,000
Bushels of corn	100,000
Bushels of wheat	30,000
Head of hogs	6,000
Head of cattle	2,000
Staves	3,000,000
Hoop-poles	1,500,000
Saw-logs	200,000
Lumber, feet	2,000,000
Bushels of coal	2,000,000

The period embraced in statement was for one year; the largest portion of the trade of Green River goes to Evansville. Some staves, hoop-poles, and lumber go to New Orleans. Most of the tobacco goes to Louisville, part by Bowling Green and thence by rail, and part by boat via Evansville. The grain goes to Alabama and Georgia via Bowling Green, and thence by rail. Considerable coal goes out of the river to Evansville, but the larger part goes to Bowling Green, and considerable is shipped from thence by rail. The coal of Green River is of superior quality, and the demand is always greater than the supply, and the supply is now tenfold more than five years ago. With additional slackwater the iron and coal fields of Nolin will be more accessible and largely increase the supply.

There are eight steamboats employed on Green River at present, two as passenger and freight boats, making two trips a week, 200 miles between Evansville and Bowling Green; the others are engaged in towing coal, lumber, staves, hoop-poles, &c., in barges, from along the river to Bowling Green and Evansville.

Our mineral deposits are comparatively undeveloped, and our fertile lands, that will produce 80 and 100 bushels of corn to the acre, are not half in cultivation.

I remain, respectfully, yours, &c.,

E. B. SEELEY,
Treasurer.

Col. WM. E. MERRILL,
Major, Corps of Engineers, U. S. A.

APPENDIX Y.

[I]MPROVEMENT OF KENTUCKY RIVER, KENTUCKY; OF BIG SANDY RIVER, KENTUCKY AND WEST VIRGINIA; AND OF GUYANDOTTE AND LITTLE KANAWHA RIVERS, WEST VIRGINIA.

[R]EPORT OF CAPTAIN JAMES W. CUYLER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 3, 1880.

GENERAL: I respectfully forward herewith the annual reports of operat[i]ons for the fiscal year ending June 30, 1880, for the several works of im[p]rovement under my charge.

Very respectfully, your obedient servant,

JAS. W. CUYLER,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Y 1.

IMPROVEMENT OF KENTUCKY RIVER, KENTUCKY.

The first appropriation for this river, $100,000, was made by the [ri]ver and harbor act of March 3, 1879, being based upon the report of [M]aj. W. E. Merrill, United States Corps of Engineers, on the survey of [th]e Kentucky River, dated January 14, 1879. The first and prerequisite [st]ep in the improvement of the river contemplated, was the reconstruc[ti]on of the five old dams, built by the State of Kentucky in 1835 to 1840, [i]n the lower 82 miles of river, and the putting in working order of their [co]rresponding locks. As the State of Kentucky owned these works [an]d the adjacent land, and as its legislature did not meet till in the [w]inter of 1879–'80, no work could be done during the working season of [1]879, as title and jurisdiction could not be passed to the United States [b]y the necessary legislation till after the legislature convened. A satis[fa]ctory act of cession to the United States of all this property having [b]een made by the legislature March 22, 1880, I, having assumed charge [of] the work and relieved Maj. W. E. Merrill, was instructed, under date [of] April 30, to submit the necessary projects, and begin operations upon [ap]proval of these. As, until the United States owned the works and [pr]operty that the State had owned, the money appropriated was *not* [av]ailable for expenditure, no data or information whereon to base

projects for actual operations had been collected. It becoming necessary to secure these immediately, careful surveys of the river at locks and dams Nos. 1, 2, 3, and 4 were set about, and, though delayed much by the continuous high stage of water prevailing, were finally made, and upon their results a detailed plan of operations matured, having in view the complete restoration of the old slackwater system as far up as Frankford, or the four lower locks and dams, covering 80 miles of the river. Under this plan, duly approved, and the estimated cost of which, as revised from the original estimate of Major Merrill and based upon the actual surveys, would exhaust the appropriation of March 3, 1879, the large amounts of timber, stone, and iron needed to reconstruct *in toto* dams Nos. 1, 2, and 3 have been procured, the necessary boats, plant, &c., provided, a large working force organized and equipped, and the work of tearing out and down these old dams, found to be of very imperfect construction originally, and now become rotten and useless, with extensive breaches in them, in which a scour had taken place, running from 20 to 50 feet in depth, was finally begun in the early part of June, 1880, the earliest moment practicable.

Good progress has been made in this work of demolition up to the 30th of June, and dams Nos. 1 and 3 are nearly ready to begin the new work on them. Quarters and kitchens have been built at the three dams to accommodate the employés, wells sunk, and the old lock-keepers' houses and out-buildings, which had lapsed into ruins from long neglect, repaired and rendered usable.

Great difficulty has been experienced in the practical conduct of the work, owing to the general scarcity and demand for labor in the surrounding country, the total lack of good means of transportation for materials and supplies, lack of speedy communication between the several works, and the bad condition of the river and the old works themselves. It is hoped that these obstacles to good progress have now largely been overcome, and that the close of this working season will see navigation of the river, practically suspended for the past six years, reinaugurated.

It is proposed to apply the funds available for the fiscal year ending June 30, 1881, $100,000, to repair and renew lock and dam No. 5, similarly to the four lower ones, and to locate and build lock No. 6, the first of the new series of works for the extension of the slackwater system up the river to the Three Forks, while with the appropriation asked for the fiscal year 1881–'82, the dam, a permanent one for lock No. 6, will be built, and lock and dam No. 7 also located and built, thus extending the new slackwater up some 50 miles.

The plan on which the present improvement is supposed to be based is that set forth in the report to the Chief of Engineers of Maj. W. E. Merrill, of date January 14, 1879.

Original estimated cost of this plan	$1,074,402 00
Total amount appropriated:	
First appropriation, March 3, 1879; last, June 14, 1880	200,000 00
Total amount expended to date	1,[illegible]

The original estimate is insufficient to carry to completion the present plan, inasmuch as the revised estimates for the work of repair on the five old works foot up to $135,000, against the original estimate of $84,802.

Probable additional sum required therefor	$50,000
Probable amount, exclusive of former appropriations, for "entire and permanent completion of present plan"	924,402

With the slackwater system "an entire and permanent completion" can be secured, a certain sum being allowed annually for maintenance and repairs. The latter in this river may be considerable, as, owing to the large quantities of massive drift brought down each spring with the sudden and high rises, it is impossible to avoid some damage occurring to the works. The five old locks are also, in my opinion, injudiciously located, and are constantly liable to choke up in their approaches, requiring dredging out to keep up the navigation.

The present low-water has disclosed the presence of large numbers of snags and stumps, which will require to be removed with active navigation resumed. To effect this, a small snag-boat, worked by horse or man power, should be fitted up and set to work removing these obstructions. I find that on the Green and Barren rivers, with an active navigation and the works well kept up, that the navigation company operating these rivers has been obliged to build and operate a similar boat. In the case of the Kentucky River this will be found even more necessary, as the quantities of drift brought down in the yearly rises are much greater than on the Green, and also heavier, while the course of the river lies in more abrupt and sharp bends.

For these snagging operations, therefore, I estimate an additional sum outside of that required for the slackwater improvement, of $5,000.

Amount that can be profitably expended during the fiscal year 1881–'82, $135,000.

Money statement.

July 1, 1879, amount available	$100,000 00	
Amount appropriated by act approved June 14, 1880	100,000 00	
		$200,000 00
July 1, 1880, amount expended during fiscal year		1,829 09
July 1, 1880, amount available		198,170 91
Amount (estimated) required for completion of existing project		942,402 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		135,00 00

Y 2.

IMPROVEMENT OF BIG SANDY RIVER FROM CATLETTSBURG, KENTUCKY, TO THE HEAD OF NAVIGATION.

The operations of the year have been in continuation of those of the previous year, to wit, improving the natural channels by the removal of obstructions in them, and by concentrating the water of low-water stages into one channel or chute over the bars and ripples, by means of a system of low riprap wing-dams, built out of the removed rock. The average length of these bars and ripples is from 100 feet to 500 feet, and the average depth over them, obtained by the improvement, is 1 foot in low-water, an average gain of about 6 inches. The appropriation of March 3, 1879, on which the operations were carried on, was exhausted by December 1, 1879, since which no operations have been carried on beyond caring for the public property of the work.

The progress made during the year, and the general condition of the work June 30, 1880, is as follows:

The raft navigation has been improved decidedly for 148 miles of river; the navigation for push-boats and light-draught steamboats also, to a certain extent, during the low-water season. The real obstructions to

this latter class of navigation consist in the bars and shoals formed by the great quantities of light, moving sand, which are continually changing in position and extent. The present plan is, therefore, incapable of affording a radical or permanent improvement of the river, though if prosecuted each year it does afford a measure of immediate relief to the surrounding country.

To effect a permanent improvement it is proposed, this fiscal year, to initiate slackwater navigation, by locating just below Louisa, Ky., the point of confluence of the two forks, a lock, and with the appropriation for the year, $50,000, purchase the necessary land, the stone and iron, prepare the detail drawings and specifications, and arrange to begin the actual construction with the moneys next appropriated.

The location of this lock is in accordance with the text of the appropriation act of June 14, 1880, and with it constructed a pool will be formed, extending some distance up the Tug and Louisa forks, affording secure harborage for the timber and coal coming down the forks, until it may be convenient to run the same out to the Ohio River.

The general plan of this work of improvement is that set forth in Maj. William E. Merrill's report to the Chief of Engineers, of date February 24, 1875, and his annual reports for 1878 and 1879, to wit, improving the natural channels for raft and push-boat navigation in low stages, while awaiting a suitable time, and the necessary funds, to begin the construction of locks and permanent dams.

Original estimated cost of 22 locks and dams	$1,922,5[illegible]
Original estimated cost improving natural channels	15,000
	1,937,5[illegible]

(First appropriation June 18, 1878; last appropriation June 14, 1880.)

Total amount appropriated	79,000 [illegible]
Total amount expended to date	23,963 [illegible]

The original estimate for improving the natural channels has been found, as was indicated by Maj. William E. Merrill at the time, insufficient; more work, for effecting this species of improvement, has been found necessary than was originally estimated for.

Probable additional sum required for completion of projects now being worked on	$60,000
Amount exclusive of former appropriations required for "entire and permanent completion"	1,872,000

The project, so far as the locks and dams are concerned, does admit of a permanent completion, a certain yearly sum being required for maintenance, repairs, &c.

The plan of improving the natural channels does *not* admit, from its nature, of a permanent completion.

THE AMOUNT THAT CAN PROFITABLY BE EXPENDED DURING THE FISCAL YEAR 1881-'82.

1. For constructing the lock and dam at Louisa, Ky., as per present plan	$60,000
2. For improving the natural channels	6,000
	66,000

The first item I consider specially important to have provided, in order to complete the lock and dam, for which much of the material will have been purchased with the appropriation for this fiscal year.

I attach hereto the report in detail of my assistant in local charge, Capt. E. A. Chase:

Money statement.

July 1, 1879, amount available	$11,708 01	
Amount appropriated by act approved June 14, 1880	55,000 00	
		$66,708 01
July 1, 1880, amount expended during fiscal year	11,671 53	
July 1, 1880, outstanding liabilities	88 33	
		11,759 86
July 1, 1880, amount available		54,948 15
Amount (estimated) required for completion of existing project		1,872,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882		66 000 00

REPORT OF MR. E. A. CHASE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 26, 1880.

CAPTAIN: I respectfully submit my report of operations on the improvement of Big Sandy River, West Virginia and Kentucky, during the months of August, September, October, and November, 1879, at that time under the direction of Major William E. Merrill, United States Corps of Engineers.

Operations were commenced August 25, and continued until November 20. The work was done entirely by hired labor, and the force employed was divided into three parties—one party on the main river and one party on each fork.

MAIN RIVER.

Between Catlettsburg, Ky., and Louisa, Ky., a distance of 26 miles, a large quantity of solid rock was removed from the bends and bed of the river; and all snags, stumps, and drift-piles were destroyed and removed from the channel.

TUG FORK.

On this fork the party began work at Louisa, Ky., and worked 35.5 miles to Warfield, Ky.

The Falls of Tug, the main obstruction in this fork, 11 miles above Louisa, were improved by lowering the head of the falls 1 foot, by widening the chute from 50 to 100 feet, building riprap wing-dams to confine the water to one channel in low-water, and by removing all bowlders and loose stone from the bed of the river.

The following shoals, Mulberry, Donathan, Ratcliff, Coply, Twin, Winding, Smith or Blankenship, Double, Stansberry or Whitt, Bull, Turkey, Big Elk, Horne, Mill, Jennie's Creek, Little, Kirk, Lick, Marrowbone, and Buck Creek, were also all improved by widening, deepening, and straightening the chutes, building low riprap wing-dams, and removing all obstructions from the channel of the river.

LOUISA FORK.

On this fork, from Louisa, Ky., to Piketon, Ky., a distance of 86½ miles, 47 shoals were improved, as follows: Twist and Wind, Twin Brother and Contrary Shoals, by blasting and breaking up the bowlders and confining the water to one channel, by means of low wing-dams built from the blasted rock.

Griffith's Creek Sand Bar, by changing the channel over bar. Fish Trap, Graves, Bumble Bee, Joe Border's Ripple, and several small shoals near Lost Creek, Chesnut, Jas. Davis, Murray Shoals, Nathan Border's Ripple, and Little White House Shoals, Big White House, Vanhouse, Red House, Wild Goose, Ward's and Greasy Shoals, were improved by blasting large rock, and removing small stones and gravel from the chutes, and repairing the old wing-dams,

The following were improved by constructing riprap wing-dams: L. Preston Ripple, Wm. Preston Ripple, Jas. Preston Ripple, Buffalo Shoals (¾ of a mile long), and Twin Maple Shoals.

The following were improved by removing rock, straightening the chutes, and making the channel wide enough for the navigation of push-boats, the only boats with which it is possible to ascend the river in low-water: Purgatory Ripple, Miller's Creek, Bird and Preston Shoals, Parter Ripple, Anxier, Hager, and Wireman's Shoals, Bay Ripple and Moody Shoals; Abbot Shoals by removing stone from channel and cutting down a sunken barge.

Middle Creek Sand Bar by removing snags and timber piles, half buried in the sand, in order that the river might resume its natural bed. Welt, Davidson, Joy, Stratton's, and Long Shoals were improved by blasting and removing bowlders and large stone from the channel.

The following table shows the season's work on the Big Sandy and its tributaries:

	Distance worked over.	Shoals improved.	Snags removed.	Stumps removed.	Fallen trees removed.	Drift piles removed.	Solid rock blasted and removed.	Loose rock removed.
	Miles.	*No.*	*No.*	*No.*	*No.*	*Cords.*	*Cub. yds.*	*Cub. yds.*
Big Sandy	26	......	579	471	2	93.4	4,052	....
Tug Fork	35.5	21	735	789	99	297.4	2,289	2,7[illegible]
Louisa Fork	86.5	47	324	136	120	148.3	609	[illegible]42
Total	148	68	1,638	1,396	221	539.1	6,950	2,951

Respectfully submitted.

E. A. CHASE,
Assistant Engineer.

Capt. JAS. W. CUYLER,
Corps of Engineers.

Y 3.

IMPROVEMENT OF GUYANDOTTE RIVER, WEST VIRGINIA.

The operations have been in general a continuation of those of previous years, viz, improving the natural channel of the river for raft navigation, by removing the natural obstructions in the river, and the artificial obstructions, in the shape of the remains of the old lock at the Falls of Guyandotte and the wreck of an old mill-dam at Little Ugly Shoals.

Summarized, the operations covered about 20 miles of river, improving and rendering easier for rafting this stretch; and with the operations of the previous year the condition of the river may be said to have been measurably improved for this kind of navigation from its mouth 49 miles up.

It is proposed with the funds appropriated for the fiscal year 1880–'81 to continue present operations, extending them up above Logan Court-House, into Wyoming, and possibly McDowell, County, with the view of improving, firstly, the raft navigation over the entire river, and *then*, if funds are left, to begin work at certain special points with the view of improving for push-boat navigation by the construction of suitable chutes.

The funds asked for for fiscal year 1881–'82, would be applied toward the continuation and enlargement of the above project.

I would also renew the recommendation of my predecessor that the mill privileges of the two private mill-dams on the river, Rogers' and Peck's, authorized by State charters, be purchased outright by the United States, or otherwise the proper legal steps taken to cancel the charters. The general plan of this improvement is that adopted by Maj. William E. Merrill in 1878. It was impossible to make an original estimate of cost for this species of improvement.

Total amount appropriated to date (first appropriation June 18, 1878; last appropriation June 14, 1880) $5,000 00
Total amount expended to date 2,691 22

No "permanent or entire completion" can be made under present project; the most that can be effected, and all that it is necessary to effect at present, is to, each year, remove the obstructions, due to the previous high-water, and gradually enlarge and extend the improvement.

AMOUNT THAT CAN PROFITABLY BE EXPENDED IN FISCAL YEAR 1881-'82.

For continuing improvement	$2,000 00
Purchase of mill privileges, probably	1,500 00
Total	3,500 00

I attach hereto report of my assistant, Mr. E. A. Chase.

Money statement.

July 1, 1879, amount available	$1,148 09	
Amount appropriated by act approved June 14, 1880	2,000 00	
		$3,148 09
July 1, 1880, amount expended during fiscal year		839 31
July 1, 1880, amount available		2,308 78
Amount that can be profitably expended in fiscal year ending June 30, 1882.		3,500 00

REPORT OF MR. E. A. CHASE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 26, 1880.

CAPTAIN: I respectfully submit a report of work done on the improvement of Guyandotte River, West Virginia, during the months of November and December, 1879, and January and February, 1880, as compiled from the office records. The work was done entirely by hired labor and was in charge of Mr. Hugh Toney, under the direction of Maj. William E. Merrill, United States Corps Engineers.

The Falls of Guyandotte, 31 miles from the mouth of the river, were improved by cutting down the old lock and removing rock, snags, and stumps from the channel, and by dredging the sand-bar just below the falls.

McComas Bend, Madison Bend, and Morris Bend were improved by blasting and removing rock and gravel from the bed of the river, and snags and fallen trees from the low-water channel.

Hamilton Shoals and King Shoals were improved by deepening the channel and removing all obstructions from the bed of the river.

At Little Ugly Shoals, 49 miles from the mouth of the river, the old mill-dam was removed, making a good channel for push-boats and timber rafts.

The following is a summary of work done during last season:

Excavation, sand-bars	cubic yards..	800
Solid rock blasted and removed	do.	300
Number snags and roots removed		2,148
Number stumps removed		200
Number fallen trees removed		600
Number leaning trees cut		400

Respectfully submitted.

E. A. CHASE,
Assistant Engineer.

Capt. JAS. W. CUYLER,
Corps of Engineers.

Y 4.

IMPROVEMENT OF LITTLE KANAWHA RIVER, WEST VIRGINIA.

The operations have been in continuation and enlargement of those of 1878-'79, and carried on with a view to render raft navigation practicable

at lower natural stages than before, and to facilitate this navigation, as well as that of push-boats on the river, from the head of the present slackwater up to Bulltown, a distance of 82 miles. To carry out this plan the natural obstructions to navigation have been removed, timber chutes provided with suitable gates built in private mill-dams to pass rafts through, which, otherwise, would be held in the pool above, and a system of low crib dikes filled in with stone built at numerous shoals to concentrate the water into one channel and regulate its flow. Good progress was made in these several departments of work, and the condition of the river on June 30, 1880, was better, for the objects had in view, than ever before; considerable, though, remains to be done to secure the work already done, and to obtain its full utilization; the means available were small for the length of river worked over, and much of the work, especially the crib dikes, were of necessity left in an insecure condition or not carried to that point of completion that is required in order that they should subserve their purpose; they are all too low and many need extension, while also in the details of construction changes are called for. I attach hereto the report of Mr. William E. Strong, the assistant engineer in charge, which gives full details.

The general plan of this improvement is based upon the report to the Chief of Engineers, of Maj. W. E. Merrill, United States Corps of Engineers, dated January 9, 1875, proposing the improvement as above indicated, and, later, the gradual extension up stream of the slackwater. permanent dams being used.

Original estimated cost, as per above report:

1. For slackwater extension	$758,400
2. Improving natural channels	7,300
Total	765,700
Total amount appropriated	58,300
(First appropriation August 14, 1876; last, June 14, 1880.)	
Total amount expended to June 30, 1880	43,300

The estimate of $7,300 for improving the natural channels has been found insufficient, firstly, because it was at the time, necessarily, but a general or approximate estimate; and, secondly, because the system actually adopted has been enlarged into one of greater elaborateness than was originally contemplated.

Probable additional sum required to perfect work now done, on improving natural channels	$10,000
Amount exclusive of former appropriations for permanent and entire completion	900,000
Amount that can profitably be expended during fiscal year 1881 and 1882	80,000

Of this sum, $70,000 will be needed to construct and complete the new lock and dam near Burning Springs, the beginning of the extension up stream of the present slackwater. With the $15,000 appropriated by act of June 14, 1880, the detail drawings for this lock and dam will be made, the land needed acquired, and a large amount of the stone for lock purchased—the sum being, however, too small to begin actual construction with. It will be very important, then, in 1881–'82, to provide funds needed to make an entire completion of the lock and dam, so that no unfinished work in either structure may be left over to suffer inevitable deterioration from the regular winter high-water and ice.

The balance asked for, $10,000, is urgently required as well, to finish the work already done, towards improving the natural river, and to se-

ure the same against a destruction likely at many works to occur at no listant time unless certain changes in construction and extensions are nade.

Money statement.

uly 1, 1879, amount available	$27,643 94	
mount appropriated by act approved June 14, 1880	15,000 00	
		$42,643 94
uly 1, 1880, amount expended during fiscal year	27,643 94	
uly 1, 1880, outstanding liabilities	243 00	
		27,886 94
uly 1, 1880, amount available		14,757 00
mount (estimated) required for completion of existing project		900,000 00
mount that can be profitably expended in fiscal year ending June 30, 1882		80,000 00

REPORT OF MR. WILLIAM E. STRONG, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 31, 1880.

SIR: I have the honor to submit the following report of operations for the improveent of the Little Kanawha River, West Virginia, during the year 1879, at that time ider the instructions of Maj. William E. Merrill.

Work on this river began May 24 and ended November 20. Three working parties, ch under the command of a superintendent, were organized. Two of these parties orked during the entire season from May 24 to November 15.

The field of operations for the first of these was from Bulltown, 130 miles above the outh of the river, to Glenville, 104 miles above. That of the second was from Glenlle to the mouth of West Fork, 48 miles above.

Both parties were engaged in the work of removing trees and undergrowth from the nks of the river, blasting and removing rock from the channel and banks, plowing d channeling bars, and especially in the construction of crib-dikes and wing-dams timber and stone.

A third party was organized for the purpose of operating a snagging-flat, which was ilt in the early part of the season at Glenville. Work was begun by this party out the 1st of August, and continued until November 20.

Their operations extended from Glenville, 104 miles above Parkersburg, to the mouth Bull Creek, 78 miles above, a distance of 26 miles.

Extreme low-water during the entire time the snagging party worked greatly hinred its progress, as much time was expended in warping the boat down the numers shoals; indeed, it was usually necessary to accumulate a head of water by build-temporary dams and take advantage of the tide created by afterward removing m.

When there was sufficient water to handle the boat its working was quite sucsful. It is but justice to the interest of this river and its improvement to call ention to the fact that such low-water as was last summer and fall was altogether precedented.

statement of the work done by the snagging party will be found in the sumry at the end of this report.

n planning the improvements on this river the end sought to be gained was a mean ween such completeness on the one hand as requires great expense, and on the other h cheap and temporary construction as with limited means would alone admit of ng over the entire ground, consequently the dikes built were on an average only ut 4 feet in height, but well and strongly built, being adapted to rafting at a minm stage of water rather than a higher.

s the range of floods is as great as 20 or 25 feet above low-water it is impossible to d the dikes of such a height as not to render them liable at times to be struck by teered rafts or boats.

s work progressed from above down stream, and as the funds were exhausted before pleting the system, several of the points greatly needing improvement have had ning done to them, and others that had been begun were left quite incomplete.

is believed, however, that in general the object aimed at was accomplished, and rafting is now practicable at a much lower stage of water than ever before, and sequently much more frequently.

DESCRIPTION OF WORK DONE.

Blasting and removal of rock from channel and banks. As one side or other of the river is usually a steep and rocky hill-side greatly promoting the accumulation of fragments of stone in such places as to become obstructions to navigation, the above class of work was required at such frequent intervals as to make special mention of localities undesirable. Wherever practicable the rock so removed was used for filling the cribs of dikes.

CUTTING AND REMOVAL OF TIMBER FROM BANKS.

The greater part of this work was done where most needed on the upper part of the river. From Bulltown to Slant's Mills, 9 miles above Glenville, the work was very thoroughly done.

Below Glenville much of this kind of work had been already done. A considerable amount was done during the season, however, and with the result of a river practically free from obstructions of this kind.

CONSTRUCTION OF CRIB DIKES.

Crib dikes were built at the following places above the mouth of the river:

	Miles.
At Buffalo Shoals	125
At Slant's Shoal	11[illegible]
At Slant's Island	117¼
At Slant's or Spicer's Mills	114
At Dusk Camp Shoal	11[illegible]
At Sand Fork Island	11[illegible]
At Lynche's Bar	111
At Fish-Pot Shoal	[illegible]
At Middle-Run Bar	[illegible]
At Muscle Shoals	[illegible]
At Rafferty's Island	[illegible]
At Laurel Shoals	[illegible]
At Leaf Bank	[illegible]
At Stocking Run	[illegible]
At Anna Maria	[illegible]
At West Fork	[illegible]

BRUSH, LOG, AND STONE DAMS

were built as follows, above the mouth of the river:

	Miles.
At Sycamore Bar	1[illegible]
At Red Oak Bar	1[illegible]
At Upper Resor Bar	1[illegible]
At Middle Resor Bar	1[illegible]
At Lower Resor Bar	1[illegible]
At Third Run Bar	1[illegible]

The crib dikes were built about 8 feet wide on top, vertical on the river face, slightly battered on the back, with base about 9 feet wide; average height, 4 feet. Cross-ties were inserted at intervals of about 10 feet between each course, and the spaces filled by hand-packing with stone. The brush and stone dams were less carefully built, but were well tied together, and are strong and durable; cross-dams connecting the main dike with the bank were also built.

In nearly every instance where dams were built more or less channeling of the contiguous bars was done. When this was omitted they were plowed and grubbed.

CHUTES IN MILL DAMS

were built at the following places, above the mouth of the river:

	Miles.
At Cutlips	124
At Spicer's	114
At Glenville	10[illegible]

These chutes were built of timber cribs filled with stone, and covered with 6-inch sheeting of oak. The dams in which they were built were from 1 foot to 18 inches higher than the laws of West Virginia allow. The chutes were kept inside of legal limits in this respect, and the difference in height from the remainder of the dam made up by a movable gate. That at Glenville was made to act automatically by water pressure and counter-balances, for a minute description of which I beg to refer you to my monthly report for the month of November. The chutes are 35 feet, 38 feet, and 40 feet wide respectively; slope, about 1.20.

SUMMARY OF WORK DONE ON LITTLE KANAWHA RIVER DURING THE YEAR 1879.

Trees cut	5,411
Trees deadened	5,107
Saplings cut	16,860
Snags cut by construction parties	9,291
Snags removed by snagging party	2,634
Cubic feet in snags removed by snagging party	90,411
Tons' weight in snags removed by snagging party	2,896
Foot linear crib dams	11,133
Foot linear brush dams	3,712
Cubic feet timber in dams	91,322
Number pounds iron in dams	998
Cubic yards stone in dams	15,863
Cubic feet timber in chutes	16,613
Pounds iron in chutes	5,667
Cubic yards stone in chutes	1,134
Cubic yards stone removed	2,834
Cubic yards gravel removed	10,400

Respectfully submitted.

Your obedient servant,

WILLIAM E. STRONG,
Assistant Engineer.

Capt. JAS. W. CUYLER.

APPENDIX Z.

IMPROVEMENT OF WABASH RIVER, INDIANA AND ILLINOIS, AND OF WHITE RIVER, INDIANA.

REPORT OF MAJOR JARED A. SMITH, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Indianapolis, Ind., July 17, 1880.

GENERAL: Herewith I forward reports of operations on the river and harbor improvements in my charge for the year ending June 30, 1880.

Very respectfully, your obedient servant,

JARED A. SMITH,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

Z 1.

IMPROVEMENT OF WABASH RIVER, INDIANA.

At the beginning of the year a contract was outstanding for building two snag-boats for the sum of $10,510. In order to commence the construction as early as possible the contract had been let before designs for the cabins were completed; these were subsequently supplied, and the boats were entirely finished and accepted August 31. The entire expense of designing, constructing, and fitting the boats with all appliances, ready for work, including all contingencies, was $7,000 each.

In constructing the two boats, it had been with the purpose of operating one of them between Terre Haute and the old dam near Mount Carmel, while the other was to be employed removing snags and attending to other work below the last-named place.

As there was a great necessity for other work besides the removal of snags, and a boat being needed for a similar purpose in the White River, authority was obtained to transfer one of the boats to that river, the cost being paid from the appropriation for its improvement.

REMOVAL OF SNAGS.

The snag-boat for the Wabash River was employed, from its completion, until December 4, since which time no results have been accomplished, owing to winter weather and high-water, the latter having pre-

vailed to a most unprecedented extent during the autumn, winter, and spring.

One hundred and thirty-six snags were removed from the river channel, most of them sawed in pieces, and all of them deposited in sloughs or such other places as seemed to give the least opportunity for their return to the channel.

The largest snag removed was computed to weigh somewhat more than 30 tons and had been a terror to navigators for many years, being known as the "white horse."

In addition to this work the boat did some excellent service as a tow-boat, for which it is well adapted.

DESCRIPTION OF SNAG-BOATS.

As the boats are of an inexpensive class, and are found admirably adapted to the service, besides being useful for various other purposes, drawings showing all the general features have been prepared, and are forwarded on a single sheet to accompany this report.

The hulls were built of pine, and are 120 feet long, 24 feet wide, and 4 feet 6 inches depth of gunwale. They have two longitudinal and three cross bulkheads for the double purpose of stiffening the boats and of preventing their sinking when punctured by snags. The boat which was sent to the White River has already been saved from sinking by this device.

Their draught of water when fully coaled is 22 inches, and ordinary speed $8\frac{1}{2}$ miles per hour. A power capstan is driven by engines having cylinders 6 inches bore and 12 inches stroke, so geared as to give 27 turns of main shaft, if desired, to one of capstan. The power may be still further multiplied by the blocks and falls which depend from heavy sheers on the bow.

The two boilers are each 22 feet long, 36 inches in diameter, and are ample to furnish steam for both propelling and hoisting engines. The cabins are plain, and sufficient to accommodate only the working crew. These boats are not expensive to work; are easily handled; can run in very little water, so that their service is available when most needed; and although in some small points they might be modified to advantage, as a whole, it is believed, their cost could hardly have been placed with better effect.

During the spring of 1880 the boats were strengthened by a better system of hog-chains, a longitudinal oak planking of the bottoms, and a plating of iron. These modifications are shown in the drawings. Other parts of the boats and machinery have also been put in better condition by the crew employed.

The original workmanship by contract was far from satisfactory, although every pains was taken to have an inspector, believed to be competent and faithful, constantly present, and the boats, when finished, presented a good appearance. Yet several important repairs and alterations were required before any work could be prudently done. My experience and judgment is that it is generally quite impossible to obtain first-class work by contract when the price to be paid is low.

DAM ACROSS NEW HARMONY CUT-OFF.

The work in progress at the close of the last fiscal year was finished September 30, 1879.

A drawing of the work as completed is shown in Plate 1 accompanying report for fiscal year ending June 30, 1879.

The work in July, August, and September consisted of remodeling ıe top of the old work, filling it with stone, and covering it with 3-inch iue plank.

Two additional cribs were built, 20 feet square and 15 feet deep, and lled with stone. Ten other cribs were completed to catch the drift bove the dam.

The following are the principal details of the work:

),206 linear feet of logs framed into cribs.
.,632 cubic yards of stone obtained and placed in cribs.
,883 pounds of drift bolts made and driven.
,500 pounds iron spikes driven.
,500 feet, board measure, of 3-inch plank fitted and spiked to top of dam.
.,500 square yards of stone paving to prevent scour of earth embankment.
.,628 cubic yards of earth and shale placed in embankment.
23 oak piles driven.

BANK PROTECTIONS NEAR GRAYVILLE, ILLINOIS.

The work in progress June 30, 1879, was completed in September and ft in a condition which is believed to be permanent.

The plan of the work is shown on Plate No. 4, accompanying the last nnual report. It now consists of a double row of piles about 5 feet part, in each row the space being filled with loose brush, the tops gen- ally passing several feet outside the outer row, and being held down y layers of stone. To prevent the piles being wrenched from place by rift or other means, they are cut off at a height not exceeding 4 feet bove extreme low-water.

The work of the season consisted in cutting and hauling to the work 50 piles 30 feet long, and driving the same an average depth of 15 feet; raightening up and redriving about the same number of old piles; ıtting and placing in work 776 cords of brush; quarrying and trans- orting by barges to the work 1,428 cubic yards of stone; sawing off ıe tops of 1,875 hard-wood piles; planting the sides of levee and bank ith willows.

GRAND CHAIN.

A small party was placed upon this work August 12, and continued ıtil the end of October, when operations were suspended owing to gh-water.

Work was confined to the last dike, that being considered the most ıportant.

Two hundred and fifty linear feet of the dike was raised to grade and ıved. The work included placing in the dike 1,927 cubic yards of one, 151 cubic yards of paving stone being purchased and transported barges to the dike.

BANK PROTECTIONS.

To protect the bank from cutting and injuring the channel near the nding at New Harmony, 91 hard-wood piles were driven a depth of 15 et. The piles were furnished and other necessary work was done by e citizens of the place.

At Hodges' Landing, 4 miles below New Harmony, a small island or owhead" throws the current against the bank, widening the channel ıere a bar already existed. The foot of the bank was therefore pro- cted by a single row of piles 5 feet apart, extending 300 feet. The les were 30 feet long, driven 15 feet, and cut off in the same manner

as at other works already mentioned; 78 cubic yards of stone were placed on the brush.

DAM ACROSS CUT-OFF AT LITTLE CHAIN.

Pursuant to the plan discussed in the last annual report, a dam of piles, brush, and stone was constructed near the head of the cut-off, as indicated on Plate 8 of report for 1879. The work consists of three rows of piles filled in with loose brush weighted down by stone. The piles are at intervals of 5 feet, and the rows are 15 feet apart. The shores are protected for 20 feet above and 100 feet below the dam.

For this work 172 hard wood piles were cut, hauled, and driven, the trees being purchased as they stood.

Three hundred and forty-eight cubic yards of stone were quarried upon the shore, and, as the water was extremely low, the stone was transported in flat-boats propelled by hand to the head of the cut-off, thence carried in carts to the dam and wheeled to its place on the brush.

WINKLER'S BAR.

As soon as the force could be spared from other works a wing-dam was commenced at this place, as indicated on Plate No. 6 accompanying the last annual report. It was, however, October, and before much work was accomplished, operations were suspended owing to high water, which has since prevailed almost continuously. One hundred and fifty-two hard wood piles were cut and hauled to the work, and 131 piles driven in the work. Two hundred and forty-three cords of brush were cut, hauled, and placed in the dam. One hundred and twenty cubic yards of stone were procured and placed on the brush. This work will be completed the ensuing season.

WARWICK'S RIPPLE.

A small party commenced work at this place in October. Notwithstanding former efforts to remove all the old coffer-dam left by a failing contractor, 55 timbers and 12 planks were found and removed from the channel.

The removal of the lower reef was first commenced with ordinary blasting powder, but was afterwards continued with dynamite exploded with platinum fuses and a dynamo-electric machine.

The work was considered largely experimental, as it was too late in the season to expect any extensive results. The only means of removing the broken rock from the channel was by men standing waist deep in water where the current was so rapid that it was difficult to keep a footing; in one instance a man was swept from the rock and carried a half mile below before reaching the shore. A part of the middle reef and all the lower one was removed, greatly improving the channel, though the work is still incomplete.

SURVEYS.

A detailed survey of the river has been made from Bone Bank to its mouth, a distance of 9 miles. This completes a continuous survey for 26 miles, besides various special surveys, all of which have been carefully reduced and platted.

CONDITION OF THE RIVER.

There are numerous snags in the channel along the entire navigable portion, notably within 10 miles of the river's mouth. At extreme low-water these snags are serious and dangerous obstructions. Several bars exist where wing-dams may be advantageously used to increase the depth of water. A constant source of injury to the channel is the undermining and cutting away of banks, thus widening the channel, filling it with snags, and doing other mischief.

The remainder of the reef at Warwick's Ripple is a serious obstruction at low-water; the Grand Chain requires considerable further work to make the low-water channel good; the Little Chain is the worst obstruction below the rapids near Mount Carmel. These obstructions were fully described in the last annual report. Another place requiring further improvement is at Coffee Island, a few miles below Mount Carmel.

With these improvements the navigation will be good at all stages of water from the mouth of the river, a distance of more than 90 miles, to the mouth of the White River.

Although numerous boats navigate the river above the rapids at this point, they will be the head of continuous navigation on the Wabash River until the old lock and dam are rebuilt.

PROJECT OF WORK FOR ENSUING YEAR.

The appropriation of $25,000 for continuing operations during the next year will be as nearly as practicable applied as follows, viz:

1. Employing snag-boat, removing snags from river, and towing barges when necessary.
2. Completing work at Warwick's Ripple.
3. Continuing work on project for improvement at Grand Chain.
4. Completing wing-dam at Winkler's Bar, and such other similar work as the available funds permit.
5. Continuing survey of channel above Little Chain.

IMPROVEMENTS NEEDED.

All the necessary work cannot be definitely described nor its expense accurately estimated until complete surveys have been extended over the entire distance. Most of them were indicated in a general way in describing the condition of the river, and it is believed that all the principal and most necessary improvements below Mount Carmel can be completed for $150,000, provided the appropriations are so made as to permit doing the work in one or two seasons. With small appropriations the most important improvements cannot be judiciously undertaken, as their cost is largely increased by being several years in progress, and there is no certainty of their completion. As a result, numerous small improvements are made which, while they benefit the navigation, are not vital, and the essential works are thus constantly left upon the list to be done in the indefinite future, and the annual estimates for their completion are but little, if any, reduced by the work already accomplished.

The invitation to commerce extended by recent improvements has been extensively honored, though the importance of the river as an outlet for the vast agricultural productions of its valley seems to be too little appreciated.

The part of the river where improvements have hitherto been made lies between two of the greatest producing States in the Union, and no part of either State is more productive than its valley.

I again submit the estimate for a lock and dam at Mount Carmel, and would recommend that a separate appropriation of not less than $25,000 be made for commencing the work and making the necessary designs for its completion.

Estimate for completing lock and dam at Grand Rapids	$130,000
Engineering contingencies	15,000
	145,000

The first collection district of Indiana is adjacent to the works of improvement. The nearest port of entry is Evansville, Ind.

Amount of revenue collected in last fiscal year, $6,596.71.

Money statement.

July 1, 1879, amount available	$34,695 56	
Amount appropriated by act approved June 14, 1880	25,000 00	
		$59,695 56
July 1, 1880, amount expended during fiscal year	33,702 39	
July 1, 1880, outstanding liabilities	989 36	
		34,691 75
July 1, 1880, amount available		25,003 81
Amount that can be profitably expended in fiscal year ending June 30, 1882.		100,000 00

Z 2.

IMPROVEMENT OF WHITE RIVER, INDIANA.

By act of March 3, 1879, an appropriation of $25,000 was made for this improvement, but as the amount was temporarily withheld from expenditure no work could be done nor preparations made during the early part of the season.

On the 2d of August authority was received to commence the work of improvement.

As my only knowledge of the river was from the hurried reconnaissance on which the project of improvement and estimate had been based, it was determined to limit the season's work to the removal of snags and to making a survey of Kelly's Ripple, which forms the most extensive obstruction in the portion of the river to be improved.

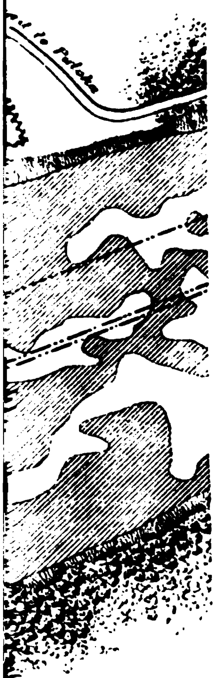
The necessary barges and apparatus were procured and the work of removing snags was begun on the 19th of August. This was continued one week, when the overseer was taken sick and suspended operations without consultation with the officer in charge of the work.

Six large snags were removed from the channel above Hazelton.

As the snag-boat was soon to be completed, work with this party was not resumed.

On the 1st of September the snag-boat started from Jeffersonville, and owing to a high stage of water was enabled to proceed at once to the White River and to pass the rapid at Kelly's Ripple.

Work with the snag-boat was continued until into the month of December, when, owing to high-water, no further work could be done and the boat was laid in a safe winter harbor on the Wabash River, near New Harmony, Indiana. Two hundred and seventy-seven snags were



order to indica
shown thus ..

B C, Dike of

E F, Limit of

removed by the boat, most of them being very large and requiring to be cut in several parts before they could be placed where they would not again enter the channel.

The weight of the largest snag as calculated by measurement was 59 tons. All were more or less imbedded in the bottom.

The bottom of the boat was several times punctured by snags and was prevented from sinking only by the water-tight compartments.

Many large piles of drift which were lodged upon the shores ready to be again floated into the channel with a rise of water were cut and burned up, and a large number of trees were cut and removed to prevent their falling into the river and adding to the obstructions already there.

The roughness of the service had been so great as to render it imprudent to attempt another season's work with the snag-boat, until after the bottom had been re-enforced and other parts of the boat strengthened. The bottom was therefore covered with oak plank and the forward rake and bows further strengthened with boiler iron.

About the 1st of June the boat and crew were again sent to the White River to resume work removing snags, but as the water remained at a very high stage the entire month no snags could be removed.

SURVEY.

In order to determine definitely the improvements required as well as the best methods to follow, a survey of the river was begun, and extended from the railroad crossing at Mount Carmel, on the Wabash River, to a short distance above Kelly's Ripple, on the White River, a distance of about 6 miles. The work has been platted on a scale of 200 feet to 1 inch and the portion covering the ripple is also platted on a scale of 100 feet to 1 inch.

WORK FOR ENSUING YEAR.

It is proposed during the ensuing year to continue the removal of snags all the time, when such work may be practicable. Further information of the river will be obtained by extending the survey already begun. Various small works are contemplated for confining the current by bank protections and wing-dams, with the purpose of making the channel deeper.

FUTURE REQUIREMENTS.

In order to connect the navigation of this river with the Wabash River at all stages of the water, it is necessary that a good channel be made past the reef at Kelly's Ripple. A careful survey of this obstruction has been made and a map showing the improvements contemplated is forwarded to accompany this report.

It is proposed to make a straight cut 100 feet wide through the reef, and 3½ feet deep measured from the surface of low-water; and to raise a dike of timber and stone 2 feet above low-water, and 20 feet wide on the north side of the cut; a small dike to be built on the south side, if found necessary. This will require the removal of 10,000 cubic yards of rock, at $1.50 per cubic yard, and the construction of 3,000 feet of dike, at 3½ dollars per foot, making a total of $25,000.

The removal of snags is of vital importance as without it no low-water

navigation is practicable. The necesssary and contingent expense of this work for one year cannot safely be placed at less than $10,000. The survey of the river should be continued during the short period of extreme low-water.

Numerous other smaller works are required for improving the channel; they will consist principally of piles, brush, and stone, but cannot be definitely described until the locations are surveyed.

The estimate for the entire improvement of the river submitted in my letter of December 31, 1878, was based upon information obtained in a reconnaissance made at the rate of 10 miles per day, and, although I believe it is as nearly correct as the data permitted, yet it is not sufficiently definite to submit as a complete project.

The agricultural and commercial interests reached by this work are very large, and I am satisfied that the benefits to be gained are largely in excess of the cost of the necessary improvements.

The work can be done more economically and the commercial interests will be correspondingly advanced by making the improvements as rapidly as possible, and I therefore recommend an appropriation of $75,000 for the year ending June 30, 1882.

Money statement.

July 1, 1879, amount available	$25,000 00	
Amount appropriated by act approved June 14, 1880	20,000 00	
		$45,000 [illegible]
July 1, 1880, amount expended during fiscal year		20,837 [illegible]
July 1, 1880, amount available		24,162 [illegible]
Amount that can be profitably expended in fiscal year ending June 30, 1882		75,000 [illegible]

Z 3.

SURVEY OF KANKAKEE RIVER, INDIANA AND ILLINOIS.

UNITED STATES ENGINEER OFFICE,
Indianapolis, Ind., February 25, 1880.

GENERAL: I have to submit the following report of a survey upon the Kankakee River, together with a general estimate of the cost of such works as will be necessary to make the river navigable by slackwater as far up as Momence, Ill., the river being already navigable above that point for 100 or more miles.

An examination of this river had been made in the autumn of 1878, under the provisions of section 2 of the river and harbor act of June 18, 1878, the report being printed as H. R. Ex. Doc. No. 73, Forty-fifth Congress, third session.

* * * * * * *

Mr. Henry Custer was employed to conduct the field and office work for constructing the maps and estimates. The field-work was begun September 2 and closed December 2, 1879.

The survey extended from the head of the present slackwater navigation, a short distance above Wilmington, Ill., to a point 1¼ miles above the dam at Momence; it was carefully made, and sufficiently in detail to afford means for devising a general plan of the necessary work and an estimate of its cost.

The entire distance surveyed is about 36 miles, and the difference in the level of the pools was ascertained to be 73.82 feet.

To connect these levels by slackwater, Mr. Custer proposes to construct three locks with lifts of 8.5 feet each, and four locks having lifts of 12 feet each, and to avoid the most rapid places in the river by canals along or near the bank a total length of 12 miles, the number of dams would thus be reduced to four, having an average height of 10.5 feet and length of 700 feet. Three of these dams are already built, but would require extensive repairs or reconstruction.

As it has been impracticable to complete all the maps on a large scale in time to accompany this report, a small map, showing the river in Illinois, with its connections, and the location of improvements suggested, has been prepared, and is forwarded herewith.

The essential works recommended by Mr. Custer are the following:

To rebuild the two dams at Momence, a total length of 649 feet and height of 6 feet, which would place the crests 6 inches below those of the present dam. Thence from a point above the lower dam a canal to be made along the river bank a distance of 4 miles, to the head of the island indicated on the map as "A." In this canal it is proposed to place two locks, each having a lift of 8.5 feet.

Thence the river channel is followed to Waldron, where the present dam is to be repaired or replaced by one 10 feet high and 580 feet long.

At Waldron a second canal is located, its length being 4,000 feet and containing a lock having a lift of 8.5 feet. Thence to Kankakee the navigation will be by river channel.

At Kankakee the present dam would be repaired or rebuilt 540 feet long and 10 feet high, the pool communicating with the next below by a canal 13,200 feet long, containing one lock with a lift of 12 feet.

The next dam occurs at Altorff, being shown in two parts, a total length of 1,054 feet and height of 16 feet. Below this place the river is rapid for a considerable distance, and requires a canal 25,350 feet long, with three locks, each having a lift of 12 feet. The foot of this canal is near Hanford's Landing, and thence the Illinois and Michigan Canal may be reached by boats drawing 4½ feet, through works already completed by the Kankakee Company. The locks of the Kankakee improvement are 100 feet long between the gate recesses, and 18 feet 3 inches wide, the recesses for the gates being 12½ feet long. They admit boats 105 feet long, 17½ feet wide, drawing 4½ feet of water, which permits a freight of 100,000 feet of lumber, or 5,800 to 5,900 bushels of corn.

As but little can be gained by making the new locks larger than those through which boats must pass to reach the Illinois River, the estimate is based upon the dimensions given, with a depth of 7 feet water over the miter-sills.

The maps thus far completed by Mr. Custer are not sufficient for a definite estimate of the excavation and other work required to construct the canals he has recommended.

The banks are described as increasing in height as the river is descended, which indicates that the adjacent lands are more nearly level than the stream. The cutting for a canal must therefore generally be to a considerable depth. The water should be at least 7 feet deep, and for present purposes I would place the average width of canal as 40 feet, which would make it cost, including all items, at least $3 per foot of length.

With this explanation, I make the following estimate:

For three masonry locks, each having a lift of 8.5 feet, at $35,000 each	$105,000
For four masonry locks, each having a lift of 12 feet, at $45,000 each	180,000
For 63,000 linear feet of canal, at $3	189,000
For construction and repair of dams	50,000
Removing reefs and other obstructions	26,000
	550,000

This amount is largely in excess of that submitted in my report of December 31, 1878, which was based upon an estimate made by Mr. E. S. Waters, the former engineer of the Kankakee Company.

A protracted illness has prevented my making such an examination of the localities and study of details as would enable me to judge whether the works proposed by Mr. Custer were the best that could be devised. I believe, however, that they are in the main well considered, and that the estimate as a total will not exceed the actual cost.

I have felt less regret at my inability to personally supervise the project for improvement than I would have had were the objections to its being undertaken by the United States, for the present at least, less numerous and forcible.

A considerable section both of Illinois and Indiana would be benefited by the work, but to what extent is not easy to ascertain. A committee of citizens was recently formed to collect statistics bearing upon this subject. In response to my inquiries a copy of the report has been furnished me and is forwarded herewith. A further statement of the probable benefits will be found in the letters of Mr. Waters, hereafter mentioned.

The Kankakee Company owns certain exclusive privileges obtained from the State of Illinois, besides rights obtained by purchase; these include the right to make the river navigable by slackwater, collect tolls, rent or lease water power, &c. In order to ascertain the status of this company and value of its franchises, the inquiry was submitted to Mr. E. S. Waters, formerly chief engineer of the company, and it is due to his courtesy that I am able to present several points of importance. Copies of his replies are appended hereto as a part of this report.

It will be seen from Mr. Waters's second letter that for the government to obtain control of the completed works and a right of way for any future constructions involves an original outlay of $300,000.

When the improvements are completed with this added expense, no other navigable waters can be reached by boats on the Kankakee save by passing through a canal not owned by the United States.

To attempt the improvement without obtaining the franchise indicated could not fail to result in litigation and expense, besides its being at least an implied encroachment upon the rights of the State.

The rights of mill-owners who are entitled to their present supply of water-power and of persons through whose lands canals must be cut would be other equally fruitful sources of trouble. Six railroads cross the river within 50 miles of its mouth, besides several bridges for ordinary travel. The railroad crossings as well as the other bridges at Kankakee, Waldron, and Momence, could not be passed with boats of any considerable size without inserting draws.

The various bridges were constructed without the necessity of authority from the United States for crossing navigable waters, and it therefore seems that any movement to cause a modification of the present

structures or of the rights under which they have hitherto existed should come from the State or local authorities.

The dams at Momence have long been a subject of contention, and an improvement could hardly fail to meet with opposition from one or other of the parties whose rights and interests are such that they cannot be disregarded.

I have thus presented the points which appear as obstacles to the improvement, together with those which I have found in its favor, as each seems fully entitled to consideration.

Very respectfully, your obedient servant,

JARED A. SMITH,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

MR. E. S. WATERS TO MAJ. JARED A. SMITH, CORPS OF ENGINEERS.

1.

WILMINGTON, ILL., *December* 19, 1879.

DEAR SIR: Your letter of the 17th instant just received, and in reply would state that I am unable to give you the desired information respecting the price that would be fixed by the Kankakee Company upon their works and franchise rights in case the general government should desire to purchase them; and have therefore inclosed your note to our officers in Boston, Mass., requesting them to answer your inquiries as to present status of the company and their valuation of the property. It was the original intention of the company to carry slackwater navigation to the State line above Momence, and a contract was made covering all the proposed works along the whole line. Owing to financial embarrassments, the work was stopped when completed to a point 10 miles above Wilmington.

Of course the business done upon the short line of navigation now completed (20 miles) gives but insufficient data for judging the amount of business that would have been done upon the river had the navigation been completed into Indiana.

Lumber and grain are mainly the products carried by boats to and from Wilmington, Hanford's Landing, and Horse Creek.

We have four competitors: The Chicago and Illinois River Railroad, which crosses the feeder; the Chicago, Alton, and Saint Louis Railroad, which crosses the river at Wilmington; the Chicago and Strawn Railroad, crossing at Horse Creek; and the Kankakee and Southwestern Railroad, which runs through Grand Prairie, cutting off much corn which would otherwise come to the river.

The amount of lumber annually carried upon the river is 5,000,000 feet, and of corn 300,000 bushels; also of oats, flax-seed, rye, and grass seeds a large number of bushels.

The first boat-load of lumber brought to Wilmington lowered the price of lumber at once $4 per M, and corn enhanced in value 1¼ cents per bushel.

The railroads, in order to secure any business from this vicinity, were obliged to reduce their freight charges from 40 to 60 per cent. It is safe to assume that the people of Wilmington and vicinity are annually benefited by this navigation $30,000.

Could the Kankakee River be joined by the Wabash, and thence by slackwater navigation and canal to Toledo via the Maumee, then, in my judgment, such a canal would be in importance second only to the Erie. I have always intended to make an instrumental survey across the summit between the waters of this river and the Wabash, but have heretofore been unable to do so.

Nothing could be gained by increasing the size of the locks until the locks upon the Illinois and Michigan Canal are enlarged, but I should favor an increase of depth to 7 feet upon the miter sills. The locks upon the Illinois River at Henry and Copperas Creek are 300 feet long and 75 feet wide, and will pass twelve canal-boats at once; but such locks are expensive to build, and costly to operate, and the advantages gained do not compensate for the increase of cost.

Yours, respectfully,

E. S. WATERS.

Maj. JARED A. SMITH,
Corps of Engineers, U. S. A.

2.

WILMINGTON, ILL., *January* 9, 1880.

DEAR SIR: Mr. Carpenter, the president of the Kankakee River Improvement Company, wishes me to inform you that his company will transfer to the United States Government "All rights under the franchises of the Kankakee Company, and all rights obtained by purchase or otherwise so far as the navigation of river is concerned for the amount that they can show vouchers for that it cost the company, and guarantee that if the amount exceeds $300,000 that it shall be transferred for that sum. We should retain our water lots and power, simply selling the right and property belonging to the navigation."

My accounts show that the dams, locks, and canal, exclusive of any land purchase, cost the company $342,773.07.

The tolls charged at present are 10 cents per 1,000 pounds upon all grain from Harford's Landing to the Illinois and Michigan Canal, and 4 cents per 1,000 pounds from Wilmington to canal; thirty cents per 1,000 feet (board-measure) on lumber to Harford's Landing, and 12 cents per 1,000 feet to Wilmington. On general merchandise the tolls are the same as on grain.

* * * * * * *

Yours, respectfully,

E. S. WATERS.

Maj. JARED A. SMITH,
Corps of Engineers, U. S. A.

APPENDIX A A.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

A A 1.

BRIDGE OVER THE OHIO RIVER AT BEAVER, PENNSYLVANIA.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., December 23, 1879.

SIR: I have the honor to submit the inclosed copy of a letter of the 6th December, 1879, from Maj. W. E. Merrill, Corps of Engineers, giving a history of the proceedings of this office in connection with the construction of a bridge across the Ohio River at or near Beaver, Pa., by the Pittsburgh and Lake Erie Railroad Company, and in obedience to the instructions of the Secretary of War of July 24, 1879; also to submit copies of the papers in the case with a view to their transmission to Congress.

The railroad company in question was required by the Secretary of War to build a dike in connection with their bridge for the protection of navigation, and failed to do so; and, in the opinion of the Judge-Advocate-General, no proceedings can be instituted in the courts to compel the railroad company to construct the dike under the act of December 17, 1872, authorizing the construction of bridges over the Ohio River.

As there appears to be no authority in the War Department to enforce the carrying out of its instructions in this case, it is recommended that the question be submitted to Congress for its information and such consideration and action as may be deemed necessary.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Brt. Major-General, U. S. A.

Hon ALEXANDER RAMSEY,
Secretary of War.

MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS, TO THE CHIEF OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, December 6, 1879.

GENERAL: In accordance with the instructions contained in your letter of the 6th of October last, I have the honor to submit the following report upon the bridge across the Ohio River, at Beaver, Pa., owned and operated by the Pittsburgh and Lake Erie Railroad Company.

When this company began work and submitted its bridge plans to the Secretary of War for approval, as required by law, a Board of Engineers, consisting of Colonel Simpson, Major Weitzel, and Major Merrill was convened at Pittsburgh to consider and report upon them.

The Board submitted a report, dated August 15, 1877,* in which they stated that the site was a particularly objectionable one in its relations to navigation, but they suggested several plans for removing or alleviating these objections, recommending that the railroad company be allowed a choice of the plan that would best suit their interests.

The company chose the plan which called for an increase of the clear width of the channel space from 400 to 425 feet, and the construction of a guiding dike extending up-stream from the left channel pier a distance of 300 feet. They accordingly modified their drawings to conform to the conditions prescribed by the Board of Engineers, and these drawings were forwarded to the Chief of Engineers and by him were submitted to the Secretary of War by an indorsement dated September 19, 1877. The Secretary of War formally approved them, and the work of building the bridge was immediately begun.

Before the bridge was completed, I received several communications from the coal shippers of Pittsburgh, protesting against the shortness (300 feet) of the guiding dike. Some of them even stated that they would prefer no dike at all to one so short.

I immediately went to Pittsburgh, visited the site of the bridge in company with many coal shippers and pilots, and decided that the complaints were well founded, that the dike was too short, and that it ought to be lengthened 618 feet, making a total length of 918 feet. I submitted a report to this effect to the Chief of Engineers in a letter dated August 26, 1878. The acting Chief of Engineers transmitted this letter to the Secretary of War in a communication dated September 2, and on September 4 the Secretary of War formally approved of the proposed increase in length of dike, and ordered that it be made by the bridge company.

On the 8th of November I received from the chief engineer of the company a drawing of the dike as he proposed to build it. It was to be 918 feet long, and to extend to the left-hand shore above the bridge. In his letter of transmittal he says "We are ready at once to begin work as soon as you have approved of same."

I replied on the same day, approving the plan. My letter was thus written more than a year ago, and although I have repeatedly written to the bridge company since then and have communicated orally with the president and some of the directors, they have thus far ignored my letters and have refused to take any step towards building any dike at all, either of the original length of 300 feet or of the modified length of 918 feet.

There can be no excuse on account of high-water, as the Ohio River has been lower this year than ever before since my official connection with it.

I believe the railroad company deny the power of the Secretary of War to change the length of the guiding dike after he had once ordered that it be made 300 feet long. But the company has not even built the 300-foot dike, although they included this dike in the original contract with the builders of the bridge. In conversations that I have had with the officers of the road they have raised objections to the extra cost of extending the dike beyond the original 300 feet. The contractor for the

* See Annual Report Chief of Engineers for 1878, Part II, page 891.

road offered to build this extension for $7,400. The case may, therefore, be summed up by saying that to save this paltry sum the company have made their bridge an obstacle and a danger to navigation, and have imperiled its legality. It is a question worth considering whether the Pittsburgh and Lake Erie Railroad Company is not liable for all injuries or delays to navigation caused by their maintenance of an illegal structure across the Ohio River.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers.

MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS, TO THE CHIEF OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, June 23, 1879.

GENERAL: I have the honor to report to the department that the Pittsburgh and Lake Erie Railroad Company, of Pittsburgh, have thus far taken no steps towards building the guiding-dike which was ordered for their bridge across the Ohio River, at Beaver, Pa., and whose construction was one of the conditions upon which their location was accepted.

They have neither built the 300-foot dike, as they agreed to in their letter to the Secretary of War, dated September 5, 1877, nor the 918-foot dike ordered by the indorsement of the Secretary of War, dated September 4, 1878, on a letter from the Chief of Engineers, dated September 2, 1878.

Inasmuch as several requests and remonstrances made by me have produced no apparent results, and as the present low-water season is exceedingly favorable for the construction of the dike, I would suggest that measures be taken by higher authority to compel compliance with the orders of the Secretary of War.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

[First indorsement.]

OFFICE OF CHIEF OF ENGINEERS,
July 3, 1879.

Respectfully referred to the honorable the Secretary of War with request for instructions.

The accompanying papers fully explain the case and the previous action taken thereon.

H. G. WRIGHT,
Chief of Engineers,
Brig. and Brevet Major-General.

[Second indorsement.]

Respectfully referred to the Judge-Advocate-General for opinion as to what legal measures should be taken to compel the company to perform its agreement.

By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

WAR DEPARTMENT, *July* 11, 1879.

[Third indorsement.]

BUREAU OF MILITARY JUSTICE,
July 19, 1879.

Respectfully returned to the Secretary of War.

It is not perceived that under the provisions of the act of December 17, 1872, relating to the construction of bridges across the Ohio River, any proceeding can be instituted in the courts to "*compel*" the railroad company to construct the dike herein specified.

The company would appear to be liable under the act only to the direction of Congress as indicated in sec. 7, or to suits in the United States district court, on the part of persons or corporations whose rights of navigation may be impeded by the construction of the bridge. Inasmuch, however, as the Department of Justice is the one which would regularly be charged with the institution of legal proceedings by the United States against the railway company if any can properly be initiated, it is suggested that the question stated in the within indorsement of reference of the Secretary of War be submitted to that department.

W. WINTHROP,
Acting Judge-Advocate-General.

[Fourth indorsement.]

Respectfully returned to the Chief of Engineers.

It does not appear from the report of the Judge-Advocate-General that there is grounds sufficient for the maintenance of a suit in law. The matter, therefore, will be brought to the attention of Congress at its next session.

By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

WAR DEPARTMENT, *July* 24, 1879.

A A 2.

BRIDGE OVER DETROIT RIVER AT OR NEAR DETROIT, MICHIGAN.

REPORT OF THE BOARD OF ENGINEERS.

DETROIT, MICH., *November* 21, 1879.

GENERAL: The Board directed to be organized by the joint resolution of Congress, to wit—

Whereas recent progress in the art has shown the practicability of constructing bridges having spans of 500 feet, or possibly more: Therefore,

Resolved by the Senate and House of Representatives of the United States of America in

Congress assembled, That the Secretary of War is hereby authorized and required to convene a Board of Engineers of the Army, whose duty it shall be to inquire into and report whether, for railroad purposes, the river Detroit can be bridged or tunneled at the city of Detroit, or within one mile above or below said city, in such manner as to accommodate the large trade and commerce crossing the river at that point and without material or undue injury to the navigation of said river; a good and sufficient tug being always kept by bridge owners to assist any craft when required—

convened at Detroit, Mich., on the 14th of October, 1879, by virtue of the following order:

[SPECIAL ORDERS NO. 213.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, September 15, 1879.

1. The follwing order has been received from the Secretary of War:

In pursuance of a joint resolution of Congress approved June 20, 1879, published in General Orders No. 67, July 3, 1879, from this office, entitled "Joint resolution relating to a bridge across the Detroit River at or near Detroit, Mich.," a Board of Engineer officers, to consist of Lieut. Col. W. F. Raynolds, Lieut. Col. Nathaniel Michler, Maj. O. M. Poe, Maj. D. C. Houston, Maj. J. M. Wilson, will convene at the city of Detroit, Mich., upon the call of the senior officer, and at as early a day as practicable consistent with the other duties of the members.

The Board will be governed by the requirements of the act mentioned, and will make its report and recommendations to the Chief of Engineers before the 1st of December next.

The junior member will act as recorder.

* * * * * * *

By command of General Sherman.

E. D. TOWNSEND,
Adjutant-General.

Official:

A. H. NICKERSON,
Assistant Adjutant-General.

The Board remained in session five days, during which time it was engaged in hearing statements and arguments of persons favoring and opposing the construction of a bridge or tunnel across the Detroit River, the substance of which is given in the record of proceedings appended to this report.

At the urgent request of all parties interested, the Board adjourned to enable them to collect statistics bearing upon the subject.

The Board reassembled on the 18th of November, and after hearing further statements and arguments as specified in the record proceeded to consider the matters referred to it.

At Detroit two immense streams of commerce come into direct interference, namely, one by water and the other by railroads. The problem before the Board was to so arrange, by either bridge or tunnel, that these might cross each other with the least injury to both, and in such a manner as to accommodate the railroad traffic, and at the same time do no material or undue injury to the interests of navigation.

The question of bridging the channel-way between Lake Huron and Lake Erie was discussed by a Board of Engineer officers in 1873, and that Board made an elaborate and exhaustive report, which is published with the Report of the Chief of Engineers for 1874, vol. 1, page 587.

The locality defined by the joint resolution of Congress is within the limits covered by the report of the Board referred to, and extends from about the middle of Belle Isle, above the city of Detroit, to or near Fort Wayne, below it a distance of a little more than 6 miles. The channel from the foot of Belle Isle to the lower limit of the city is straight, running about twenty-five degrees south of west, and then changes twenty degrees more to the southward.

The width of the channel on either side of Belle Isle is about 2,000 feet, its greatest depth on the northerly side being from 25 to 30 feet, and on the southerly from 30 to 40. Below Belle Isle the greatest depth varies from 39 to about 50 feet.

The question of bridging or tunneling the river near Detroit has been agitated for several years, and numerous plans and projects therefor have been proposed; several of these have been presented for consideration, but as the joint resolution of Congress, embodying the only instructions the Board has received, does not require a discussion of modes, plans of construction, details of operation, or the matter of cost, these subjects, except in a general way, are not referred to in this report.

The magnitude of the conflicting interests at this point may be realized from the official statement that the number of vessels of various kinds passing Fort Gratiot light-house during the fiscal year ending June 30, 1879, was 22,150. The business of the railroads crossing the river at Detroit during the year 1878 was as follows, viz:

129,113 passengers.
12,258 passenger-cars.
3,873 baggage-cars.
104,359 freight-cars.

The joint resolution contemplates two modes of crossing; first, by a bridge; second, by a tunnel.

BRIDGE.

The conclusions to which the Board of 1873 arrived are as follows, viz:

1st. That a bridge giving a clear headway of 150 feet, and clear spans of 400 feet, would not seriously injure navigation, but would be very expensive, involving long, and in some places inconvenient approaches.

2d. That no bridge giving passage to vessels by draws alone, with draw-spans at present practicable, can be permitted without serious injury to navigation.

3d. That a bridge giving a clear opening of 700 feet from April 1 to December 1, with two draw openings 100 feet in the clear, and with the permanent foundations of its movable piers 18 feet below lowest stage of water, will not be a serious obstacle to navigation.

4th. For the reasons heretofore given, although the question has not been directly referred to it, the Board deem the crossing of the river by tunnels the only unobjectionable method; and from all information they have obtained think a tunnel at Detroit * * * is by no means impracticable, at a cost not so great as to debar it construction.

That Board also stated that no bridge with draws should be tolerated. There is probably no difference of opinion about these conclusions, except as to the one referring to a bridge with draws.

The form of bridge considered inadmissible by the former Board had "a clear headway of only 12 feet provided with two pivot draws, each leaving two openings of 166 feet in the clear, and the remainder of the structure built on piers of masonry 200 feet apart."

It is believed that draw-openings of 166 feet were the greatest then considered practicable; draws of more than 200 feet have been since constructed, and it is now proposed by bridge-builders of high reputation to construct them with openings of 300 feet on each side of a pivot pier, or of 400 feet between two pivot piers.

Those who favor the construction of a bridge over the river now admit that vessels should have the right of way, and say that the draw should always be kept open, except when necessary for the passage of trains at such times as will not interfere with the passage of vessels.

It is the opinion of the Board that, with skillful navigators there will be no material difficulty in passing through clear openings of 300 or 400

feet at any time when it would be safe to navigate the river. With the right of way clearly and emphatically given to navigation there would then be no material or undue injury to that interest.

If vessels have the right of way, can the traffic across the river be accommodated?

The Board has investigated this matter and finds that with the present traffic there will be ample time during the intervals between the passing of vessels to move all the trains across the bridge. There will occasionally be delays, but the railroads can accommodate their time tables to compensate for any ordinary delays.

Should the traffic increase so that there would not be sufficient time to pass all trains during the season of navigation, the additional cars can be crossed by the ferriage system as at present. This system need not be wholly abandoned, but should be kept available, in case of necessity; indeed it might be requisite, in order to assure regularity of passenger-trains, to depend altogether upon the ferriage system for their transit during the season of navigation.

LOCATION OF BRIDGE.

The Board is of the opinion that the bridge should be located at a considerable distance above or below the business portion of the city, so that its use will not be interfered with by the local traffic in front of the city in that part of the river which forms the harbor of Detroit. The two points which seem best suited to the purpose are:

1st. At the lower end of Belle Isle. This is understood to be the least objectionable to the interests opposing the construction of a bridge.

2d. In the vicinity of the foot of Twenty-fouth street, in the city of Detroit.

GENERAL DESCRIPTION OF THE BRIDGE.

There should be placed near the middle of the main channel, on the usual course of through vessels, either a draw-span, with a clear opening of not less than 300 feet on each side of the pivot-pier, or a single clear opening not less than 400 feet between the pivot-piers of two adjacent draw-spans, and, in addition, at least one other draw-span, with a clear opening of not less than 166 feet on each side of the pivot-pier, placed so as to be used for convenience, or in case of accident to the main opening.

The fixed spans should not be less than 450 feet in the clear, and those adjacent to the main opening should have a clear headway of not less than 60 feet, which height is readily attainable, without extraordinary grades.

A considerable portion of the craft plying the lakes will be able to pass under a bridge of this height, and thus obviate the necessity of opening the draw so frequently.

The Board would remark that it is not intended to convey the impression that it is of the opinion that such a bridge as has been described will not be to some extent an obstruction. The language of the joint resolution "material or undue injury," contemplates that there may be some obstruction, and the question the Board has considered is; whether, in view of the great interests involved, a bridge can be constructed which will fulfill these conditions. A good and sufficient tug, as contemplated by the joint resolution, would at times be of assistance in passing the bridge.

In case authority to construct such a bridge in this locality should be

granted by Congress, it should be distinctly provided that vessels have the right of way, and the draw be kept open except when trains are passing. That the plan and location be subject to the approval of the Secretary of War; that its construction be subject to his supervision so far as relates to interference with navigation, and severe penalties should be prescribed for any violation of these provisions.

THE TUNNEL.

The Board is unanimously of opinion that the most complete solution of the problem is the construction of a tunnel under the river.

This may be located at any point within the limits prescribed by the joint resolution; it is deemed practicable, and if properly constructed will accommodate the railroad traffic, and be no obstruction whatever to navigation.

The following papers are respectfully submitted:

No. 1. Letter of citizens' committee of Detroit, in favor of a bridge.

No. 2. Letter of General C. B. Comstock, in reference to currents in the Detroit River.

No. 3. Address of Mr. J. F. Joy, in favor of a bridge.

No. 4. Resolutions of the Cleveland, Ohio, Board of Trade, against a bridge.

No. 5. Statement of vessels which passed Fort Gratiot from July 1, 1877, to October 23, 1879.

No. 6. Statement of vessels passing Grassy Island light during the fiscal year 1879 and the portion of the year 1879 previous to September 30.

No. 7. Resolution of the Saint Paul, Minn., Chamber of Commerce, protesting against a bridge.

No. 8. Letter from Commander W. R. Bridgman, U. S. N., referring to number of vessels passing Grassy Island light-station.

No. 9. Letter of the governor of Minnesota, transmitting a copy of a letter to the honorable Secretary of War protesting against a bridge.

No. 10. Number of vessels passing Detroit, Mich., from April 27 to October 31, 1879.

No. 11. Letter from R. A. Alger and M. S. Smith, favoring a bridge.

No. 12. Letter of James McMillan, chairman of citizens' committee of Detroit, giving number of passengers, passenger and baggage cars crossing at Detroit from the year 1875 to 1879.

No. 13. Abstract showing number of vessels passing Windmill Point light-house, Fort Gratiot light-house, and the Saint Clair Flats lower light.

No. 14. Resolution of the Buffalo Board of Trade, against a bridge.

No. 15. Proceedings of the Board of Engineers. [Not printed.]

All of which is respectfully submitted.

W. F. RAYNOLDS,
Lieutenant-Colonel of Engineers, Brevet Brigadier-General, U. S. A.
N. MICHLER,
Lieutenant-Colonel of Engineers, Brevet Brigadier-General.
O. M. POE,
Major of Engineers, Brevet Brigadier-General.
D. C. HOUSTON,
Major of Engineers, Brevet Colonel.

To the CHIEF OF ENGINEERS, U. S. A.:

I fully concur in the above report as far as relates to the tunnel, but, after a careful examination of the whole subject, I am satisfied that any bridge other than a high one, with spans of at least 450 feet, will be an undue impediment to navigation, and I am not prepared to approve the construction of a drawbridge that I believe a majority of those interested in lake commerce will pronounce a material obstruction to the navigation of this great national highway.

JOHN M. WILSON,
Major of Engineers,
Brevet Colonel, U. S. A.

No. 1.—LETTER OF CITIZENS' COMMITTEE OF DETROIT IN FAVOR OF A BRIDGE.

DETROIT, MICH., *October* 16, 1879.

GENTLEMEN: We, the members of the citizens' committee deputed to present to your honorable Board facts and figures in support of the necessity for and practicability of having a bridge across the Detroit River at or near this city, for railroad purposes, beg to make the following statement:

The present mode of transportation during the entire year of the railroad traffic, across the Detroit River at the city from the Michigan Central slip docks is by car ferry boats, in a southeasterly direction, a distance of about 6,000 feet, and from the Milwaukee Railroad slip, in a southerly course, a distance of about 3,000 feet, to the Canadian shore and Great Western Railway slip docks.

These boats convey each 14, 12, and 8 freight cars at one time; the number of cars ferried at this point during this year will be about 300,000, representing a tonnage of about 3,600,000 tons exclusive of about 180,000 passengers, and United States through and local mails and express. This traffic is largely on the increase, and if the bridge crossing is granted it is safe to say this tonnage and business will be quickly doubled. We append statement showing how this traffic has increased, even with the imperfect means now in use.

The delay, risk, and terrible expense during five months of the year in forcing boats through the very thick and sometimes grounded ice, ferrying this traffic—when all other navigation on the river except ferries is closed—is a very serious drawback to transportation to and from the eight Michigan railroads converging at this city. This fact alone should be sufficient to warrant the construction of a bridge for the passage of this traffic.

We say *bridge*, because from the large sums of money already expended by the railroad companies in boring the bed of the river within the boundary named in your commission, and in sinking shafts and excavating several drifts under the bed and upon both sides of the river at what were supposed the best locations, we are satisfied that the expense of constructing a suitable and reliable double-track and drainage tunnel is prohibitory to such a mode of crossing.

A bridge of reasonable height above the surface of the water, with draws of not less than 250 feet in the clear, perhaps larger openings, can be constructed, and these draws can be worked so expeditiously and in such a manner as will give the vessels a safe right of passage at all times, and satisfy the railroad companies in the transit of their trains of passengers, live stock, and freight.

The bridge can be located at such a point upon the river as will enable the men in charge to see vessels approaching from either direction when a long way distant, and as the draw-bridges, during the seven months of navigation, would remain open for the passage of vessels, and be closed only when trains require to cross, and when no vessels are in close proximity to pass through, there should be no reasonable objection on the part of vessel-owners to this structure.

The proposed draw-openings would give a very much greater area for navigation up and down the river than the same vessels now have in the Lake Saint Clair Ship Canal, through which all the shipping passes with safety, under far more disadvantageous circumstances than a bridge in this river can possibly present.

The railroad or bridge company's tugs, at their expense, would be in readiness at all times when necessary to assist vessels approaching and passing through the draws.

Of course the plans would be submitted to the Secretary of War for his approval before construction.

To give you some idea of the volume of traffic passing to and from our Michigan railroads centering in this city, we append the following statement of cars ferried to and from the Great Western Railway slips; and if the bridge is constructed here, you can consistently add one-half to the figures of 1879 as a low estimate of the traffic that would at once cross—that would be at least 5,400,000 tons—because we are assured the Canada Southern Railway traffic for Detroit and its districts, in place of crossing at Grosse Isle, and reaching Detroit via Trenton, at 18 miles distant, would come to Windsor and Detroit via the proposed Essex Center Line and bridge.

Year.	Cars.	Tons.
1873	160,212	1,922,544
1874	167,480	2,000,760
1875	156,675	1,880,100
1876	173,859	2,086,281
1877	161,597	1,939,164
1878	194,359	2,332,808
1879	300,000	3,600,000

To which add the proportion of tonnage from the Canada Southern, which would make, as we have said, about 5,400,000 tons per annum.

All this is exclusive of passengers, mails, and express.

Having submitted a plan showing both shores of the Detroit River, with the various lines of railroad approaching thereto, and also plans of proposed bridges, we beg your favorable consideration of them, and shall be happy to wait upon you at any time or place indicated, and furnish any additional information required.

We are yours, respectfully,

JAMES MCMILLAN,
ALANSON SHELEY,
JAMES F. JOY,
G. V. N. LOTHROP,
W. K. MUIR,
Of Citizens' Committee.

To the BOARD OF UNITED STATES ENGINEERS
Commissioned to examine and report upon the crossing of the Detroit Rivev for railroad purposes by bridge or tunnel, within one mile above or below the city of Detroit.

NO. 2.—LETTER OF GENERAL C. B. COMSTOCK, MAJOR OF ENGINEERS, IN REFERENCE TO CURRENTS IN THE DETROIT RIVER.

OFFICE OF UNITED STATES LAKE SURVEY,
Detroit, Mich., October 16, 1879.

SIR: At your request, Mr. D. F. Henry has examined some of his note-books of 1869, and states as follows:

"I find the following velocities of the river given in the note-books of the 'outflow' in 1869, October and November. They are not exactly located, as they were only taken in testing meters—part of them in fast and part in slow currents.

"Near the head of Belle Isle in the Canada channel two series of observations giving 2,525 and 2,672 feet per second, or about 1¾ miles per hour.

"In the same channel farther down, at 10 feet depth, 2,200; at 20 feet depth, 2,146; and at 25 feet depth, 2,025 feet per second, or about 1½ miles per hour.

"In the American channel near the foot of Belle Isle, near the surface, two series, giving 1,680 and 1,726 feet per second, or about 1¼ miles per hour."

Very respectfully,

C. B. COMSTOCK,
Major of Engineers,
Brevet Brigadier-General, U. S. A.

General W. F. RAYNOLDS,
U. S. Engineers, Detroit, Mich.

No. 3.—ADDRESS OF MR. JAMES F. JOY, IN FAVOR OF A BRIDGE.

DETROIT, MICH., *October* 18, 1879.

GENTLEMEN: In my statement before you this morning I gave the number of vessels passing the river at Detroit, as reported by the marine reporter for the press, as follows:

	Passing up.	Passing down.
Propellers	961	1,041
Steam-barges	979	1,151
Schooners	2,468	2,253
Total	4,408	4,445

In all	8,853
The barges which were towed were not included in this, which are estimated at	1,500
All told, making a grand total of	10,353
Take the schooners together, and barges towed both ways, and they number	6,221
Then the propellers and steam-barges together, and they number	4,132
Making a total of	10,353

Assume that the schooners and barges towed are three in a tow, and you have 2,074 tows. Added to the number of steam-barges and propellers, and you have 6,205 passages through the draws in the course of a year.

There are in the seven months of navigation 5,136 hours; you have one and one-fifth passages in an hour, on the average, and these at very irregular times, and sometimes several hours intervening. With this navigation there is a very large space of time left for the passage of trains, even if there is only one draw. These are the vessels that do the great commerce of the lakes. The other craft of all sorts and sizes, which come and go from the port of Detroit, Mr. Bissel thinks, amount to as many more.

These craft include scows for wood and lime, and every possible kind of small boat which come to and go from Detroit. These are a loose craft, engaged in no long trade. They are small craft; they are easily managed, quickly handled, might go through a draw 250 feet wide, sideways, two or three end to end, at once.

So far as that class of craft is concerned, as I have said, there is no difficulty in handling it, and a vast quantity of it would not go through a draw in any event—much of it wood-scows, engaged in traffic in and around Lake Saint Clair and Saint Clair River in bringing wood, lime, and stone to this city, and other supplies of various kinds from below as well as above.

But suppose we estimate that every one of them wants to go through a draw every time they want to come to Detroit, and want to go through singly, which is not at all supposable, then we should have about 16,000 passages. That would be about three in one hour, on an average, with one draw. But all these might pass the draw not used by the vessels engaged in the long trade. This small craft passing singly would go through the draw in two or three minutes. A long tow would take some longer; but when you consider how irregularly they go and sometimes two or three together, up and down, I think we may fairly estimate that one-half of the whole time may be left to the railroad companies, if, as I say, there were but one draw, to pass and repass the bridge with their trains, which is very much greater time than would be required for that service. With the two draws in use there would be still much more time for railway trains to pass. With a double-track bridge, and with openings altogether equal to 1,000 feet for all these various kinds of craft to pass through, it can hardly seem possible that there ought to be any difficulty in accommodating both the railways and the commerce of the country, while the one passes over and the other passes along the river. This small craft stopping at Detroit and starting from there is not like the large vessels and propellers engaged in the large commerce of the lakes, which ordinarily pass by Detroit on its way up and down the lakes. That kind of vessel, whether passing in tows or singly, ought to have the right of way, and the passage of trains should give way to them.

The smaller craft, stopping and starting from Detroit largely and so easily managed, need not necessarily have the right of way, and can easily pass either draw. It is for this reason that I have suggested that there should be no iron rule concerning the use of the bridge. The use of it, and the rules for passing of vessels, should be all the time under the control of the Secretary of War. He can have, and from time to time make, such rules as are found expedient and necessary, having reference to the kind of craft which may pass through. I inclose the note which contains my figures.

I will add that cases have frequently come before the Supreme Court of the United States for collision against bridges. In order that the commission may have before it the law and the reasons of it, I will allude to a late one which occurred on the Mississippi River, which came before that court, and which I now mention because the court took occasion to dispose of the complaints of those engaged in navigation and used language especially applicable to Detroit River. The language used by it also has a direct bearing upon the language of the order of the Secretary of War, and the resolution of Congress. I mean the words "undue injury to navigation caused by building a bridge."

The case is that of the Mohler, a steamer drawing barges loaded with wheat down the river. It is found in the 21st Wallace's S. C. Reports, page 230.

The barge towed was wrecked by collision with one of the piers of a bridge just above Saint Paul, and totally lost. The wind was blowing; high bluffs line the side of the river and prevent boats feeling the wind till just before reaching the bridge, when they recede and open, and do not operate as a protection against the wind. On reaching that point in the river the wind would be strongly felt by the boat. It was very heavy, as was testified, when the boat reached the bridge. It was too late to change the course of the boat or make a landing, and collision was inevitable, according to the testimony.

It would be well for the commission to read the whole case, but I quote the language of the court which meets the point I wish to make. It was the unanimous opinion of the whole court:

"Any prudent officer would have stopped until the weather became calm. At any rate it was the duty of the master of the boat in question to have done so, and, failing in this duty, he is chargeable with the consequences of his negligence, which in this case were

lamentable, for not only was the property in his charge destroyed, but a human life lost.

"The officers of steamers plying the western waters must be held to the full measure of responsibility in navigating streams where bridges are built across them. These bridges, supported by piers, of necessity increase the dangers of navigation, and river men, instead of recognizing them as lawful structures built in the interests of commerce, seem to regard them as obstructions to it, and apparently act on the belief that frequent accidents will cause their removal. There is no foundation for this belief. Instead of the present bridges being abandoned more will be constructed.

"The changed condition of the country, produced by the building of railroads, has caused the great inland waters to be spanned by bridges; these bridges are, to a certain extent, impediments in the way of navigation, but railways are highways of commerce as well as rivers, and would fail of accomplishing one of the main objects for which they are created, the rapid transit of persons and property, if rivers could not be bridged. It is the interest as well as the duty of all persons engaged in business on the water routes of transportation to conform to this necessity of commerce; if they do this and recognize railroad bridges as an accomplished fact in the history of the country, there will be less loss of life and property, and fewer complaints of the difficulties of navigation at the places where these bridges are built. If they pursue a different and contrary course it rests with the courts of the country in every proper case to remind them of their legal responsibility."

This case places strikingly before you what kind of obstructions are not an undue impediment to navigation; and also the necessity of bridges, and as many as the commerce of the country requires, and the fact that commerce goes by the rail as well as by water, and that to some extent the one must give way to the other, and that both must be so managed and treated that all the ways of commerce must be opened, and that neither shall act or be protected to the undue prejudice of the other, and especially that one shall not and cannot claim free and entirely unrestricted passage to the great detriment of the other.

The bridge is a necessity, and navigation must recognize it, and then both must, in a friendly way, and under some general regulations made by the department, so conduct their business as in the least degree to injure each other.

I am, with great respect, yours truly,

JAMES F. JOY.

To the BOARD OF UNITED STATES ENGINEERS
Commissioned to examine and report upon the crossing of the Detroit River for railroad purposes, by bridge or tunnel, within one mile above or below the city of Detroit.

MARINE OFFICE,
Detroit, Mich., October 17, 1879.

Mr. James Westcott, the marine reporter at this port, had published at the close of navigation last year in the Detroit papers the following statement regarding vessel passages during the season of 1878:

Passed down.		Passed up.	
Propellers	1,041	Propellers	96[illegible]
Steam-barges	1,151	Steam-barges	97[illegible]
Schooners	2,253	Schooners	2,4[illegible]
Total	4,451		4,4[illegible]
		Total	4,4[illegible]
		Grand total	8,8[illegible]

It was stated that the above did not include barges that were towed either way which may be safely estimated at not exceeding 1,500 more; this added would make the whole number 10,359, and from my own experience I believe the statement correct.

J. W. HALL.

Hon. JAMES F. JOY.

NO. 4.—RESOLUTIONS OF THE CLEVELAND, OHIO, BOARD OF TRADE AGAINST A BRIDGE.

BOARD OF TRADE ROOMS,
Cleveland, Ohio, October 18, 1879.

SIR: I have the honor to inform you that at a regular meeting of the Cleveland Board of Trade held to-day, the following preamble and resolutions were unanimously adopted:

Whereas the Board of Trade of this city is informed that the Board of Engineers provided for by the joint resolution of Congress to examine and report as to the feasibility of bridging or tunneling the Detroit River are now at the city of Detroit, and ready to proceed with their work; and believing that each city on the line of the northern chain of lakes is deeply interested in this subject, and that Cleveland should protest with others against any plan that will in any way obstruct a free use of the Detroit River for the large commercial traffic passing through that noble line of communication: Be it, therefore,

Resolved by this board, That not any obstruction be placed across said river at any point by way of a bridge, believing that such structure would greatly interfere with the free navigation of that stream, and delay the passsage of sail, steam, and other water craft navigating the same, while the interests of the railroads and the public can as well be served by the construction of a tunnel under said river.

Resolved, That R. K. Winslow, esq., Capts. A. Bradley and W. B. Guyles constitute a committee, and that they have full power from this board to watch the interests of the lake, and carry out the intent of these resolutions in conjunction with other cities cities interested.

Resolved, That the secretary be required to forward a copy of these resolutions to Col. W. F. Raynolds, chairman of the investigating board at Detroit.

Yours, truly,

THEODORE SIMMONS,
Secretary.

Mr. W. F. RAYNOLDS,
Chairman Board of Engineers.

No. 5.—*Statement of vessels which passed Fort Gratiot light from July 1, 1877, to October 23, 1879.*

Month.	Fiscal year ending June 30, 1878.							Fiscal year ending June 30, 1879.							Quarter ending September 30, 1879.*						
	Barges.	Barks.	Brigs.	Schooners.	Scows.	Steamers.	Total.	Barges.	Barks.	Schooners.	Scows.	Steamers.	Brigs.	Total.	Barges.	Barks.	Brigs.	Schooners.	Scows.	Steamers.	Total.
July	664	74	15	1,270	259	1,724	4,006	503	60	838	132	1,268	3	2,804	740	74	4	1,166	166	1,541	3,691
August	643	99	14	1,301	218	1,611	3,886	600	76	911	190	1,328	7	3,112	739	94	11	1,161	195	1,561	3,761
September	646	117	12	1,243	191	1,653	3,862	684	77	951	188	1,343	11	3,254	940	82	8	1,390	189	1,635	4,264
October	553	96	14	1,100	90	1,563	3,416	531	67	871	118	1,357	3	2,947	693	70	8	1,162	131	1,450	3,514
November	345	43	1	582	56	1,012	2,039	455	42	612	73	1,045	......	2,227	....	......	.....	......	......	......	......
December	17	......	......	14	3	91	125	24	2	41	8	121	......	196	....	......	.....	......	......	......	......
January	......	......	......	......	1	4	5	......	......	......	......	......	......	......	....	......	.....	......	......	......	......
February	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....	......	.....	......	......	......	......
March	4	......	......	5	15	66	90	......	......	......	......	28	......	28	....	......	.....	......	......	......	......
April	364	57	1	581	78	1,000	2,081	116	8	71	27	208	......	430	....	......	.....	......	......	......	......
May	660	74	4	939	163	1,424	3,264	679	120	1,006	205	1,461	2	3,473	....	......	.....	......	......	......	......
June	612	98	12	1,088	188	1,438	3,436	803	71	1,090	167	1,546	6	3,683	....	......	.....	......	......	......	......
Totals	4,508	658	73	8,123	1,262	11,586	26,210	4,395	523	6,391	1,108	9,705	32	22,154	3,112	220	31	4,879	681	6,207	15,230

* Including twenty-three days of the month of October, 1879.

No. 6.—STATEMENT OF VESSELS PASSING GRASSY ISLAND LIGHT DURING FISCAL YEAR 1878, AND THE PORTION OF THE YEAR 1879 PREVIOUS TO SEPTEMBER 30.

OFFICE OF LIGHT-HOUSE INSPECTOR, TENTH DISTRICT,
Buffalo, N. Y., November 5, 1879.

SIR: In compliance with instructions from the Light-House Board of date the 24th ultimo, I send you subjoined a statement of the vessels reported by the keeper as passing Grassy Island light-station during the fiscal year 1878 and that portion of the year 1879 previous to September 30, as follows, viz:

Steamers.	Barges (towed).	Brigs.	Schooners.	Scows.	Rafts.	Total.
11,884	4,946	862	8,046	2,012	68	27,818

Very respectfully,

W. R. BRIDGMAN,
Commander, U. S. N., Light-House Inspector, Tenth District.

Gen. W. F. RAYNOLDS, U. S. A.

No. 7.—RESOLUTION OF THE SAINT PAUL, MINNESOTA, CHAMBER OF COMMERCE PROTESTING AGAINST A BRIDGE.

CHAMBER OF COMMERCE,
Saint Paul, Minn., November 21, 1879.

GENTLEMEN: In accordance with the resolutions of the Chamber of Commerce of this, the chief commercial city of the State, copy of which is hereto appended, I have the honor, on the part of that body, respectfully to protest against any project for building a bridge across the Detroit River. The people of Minnesota, in common with those of the other States bordering upon the upper lakes are deeply interested in the maintenance, intact, of communication by water with the ocean, and they are unanimous in remonstrating against obstruction to free and safe navigation. The vast products of this State, and of the Territories west of it, which are rapidly augmenting from year to year with the influx of population, can with difficulty even now be transported to the markets of the East, with all the facilities that can be afforded, and it is of vital importance to this new Northwest that every practicable outlet for freight be enlarged, rather than diminished by the erection of such barriers to safe transit as a bridge of any kind over the Detroit River.

Very respectfully, your obedient servant,

HENRY W. SIBLEY,
President.

To the honorable BOARD OF ENGINEERS.

RESOLUTIONS.

Resolved, That this chamber does earnestly protest, on behalf of the commercial interests of this State, against the construction of a bridge across or the erection of any obstruction to navigation in the Detroit River, which is the gateway of all the commerce of the Northwest; and we hereby request the president of this chamber to draw and forward to the honorable Board of Engineers about to consider and determine the question of the construction of such a bridge a formal protest against such construction, accompanied by such statements and statistics as have a bearing upon the question involved.

Resolved, That the president of this chamber be requested to wait upon the governor of this State and request him to prepare and forward to the honorable Secretary of War an official communication setting forth the great interests of Minnesota involved in the construction of such a bridge across the Detroit River, and earnestly protesting against such construction, and that the governor be requested to forward a copy of such letter to the said Board of Engineers.

Resolved, That our Senators and Members in Congress be requested to co-operate with the governor in resisting the proposed scheme of constructing a bridge across the Detroit River.

No. 8.—LETTER FROM COMMANDER W. R. BRIDGMAN, U. S. N., REFERRING TO THE NUMBER OF VESSELS PASSING GRASSY ISLAND LIGHT-STATION.

OFFICE OF LIGHT-HOUSE INSPECTOR, TENTH DISTRICT,
Buffalo, N. Y., November 12, 1879.

SIR: As the language of my letter of date the fifth instant is apparently ambiguous, I desire to say further that the statement therein given is an exhibit of the number of vessels reported as passing Grassy Island light-house between July 1, 1878, and September 30, 1879, both dates inclusive.

Very respectfully,

W. R. BRIDGMAN,
Commander, U. S. N., Light-house Inspector, Tenth District.

General W. F. RAYNOLDS, U. S. A.

No. 9.—LETTER OF THE GOVERNOR OF MINNESOTA TRANSMITTING A COPY OF A LETTER TO THE HONORABLE THE SECRERARY OF WAR, PROTESTING AGAINST A BRIDGE.

STATE OF MINNESOTA, EXECUTIVE DEPARTMENT,
Saint Paul, November 14, 1879.

GENTLEMEN: By request of the Saint Paul Chamber of Commerce, I have the honor to transmit herewith a copy of a letter addressed by me to the Hon. Secretary of War, protesting against the construction of the proposed bridge across Detroit River, as a serious obstruction to the free navigation of the great lakes, and detrimental to the commercial interests of Minnesota and of the vast country to the northwest.

Very respectfully,

J. S. PILLSBURY,
Governor Minnesota.

To the honorable BOARD OF ENGINEERS.

STATE OF MINNESOTA, EXECUTIVE DEPARTMENT,
Saint Paul, November 14, 1879.

SIR: In compliance with a resolution of the Chamber of Commerce of Saint Paul and pursuant to my own convictions upon the subject, I beg leave to respectfully but earnestly protest against the construction of a bridge across Detroit River, the consideration of which I understand is to be before the Board of Engineers to meet in Detroit on the 18th instant.

I need scarcely state that the vast and growing commercial interests of this State and of the rapidly settling country north and west demand unobstructed navigation through the great lakes and their connecting channels.

It is indeed difficult to exaggerate the magnitude of these interests or the rapidity of their development. The annual wheat export of this State alone averages 25,000,000 bushels, a large proportion of which seeks water transit to the seaboard, via the great lakes. A much larger proportion of the growing products of Dakota are dependent upon this route alone for the means of reaching a market, while the transportation which will be required with the development of the agricultural and mineral resources of the vast country drained by the Northern Pacific Railroad baffles computation. An ample and unimpeded water communication must for a long time be the only defense of these growing interests against railroad combinations, with whose freight exactions they are constantly threatened. Anything, therefore, which jeopards this free water transit as a means of competition in transportation is justly a cause of alarm. That the proposed bridge over the Detroit River will prove an obstruction to such free navigation cannot be doubted, and I therefore, in behalf of the people of this State, of the vast country whose interests are deeply involved, protest against its construction.

Most respectfully, your obedient servant,

J. S. PILLSBURY,
Governor Minnesota.

Hon. GEORGE W. MCCRARY,
Secretary of War.

NO. 10.—NUMBER OF VESSELS PASSING DETROIT, MICHIGAN, FROM APRIL 27 TO OCTOBER 31, 1879.

DETROIT, MICH., *November* 17, 1879.

DEAR SIR: Of the class of vessels that I report there have passed here from April 27 to October 31—

As taken from my books	16,196
Estimate for November, same average	2,598
Small craft that I do not report	12,600
	31,394

Yours, very respectfully,

J. W. WESTCOTT.

GEO. W. BISSELL, Esq.

The number of tons transported through the river during the season of 1879, the month of November being estimated on the basis of the previous part of the season, was 12,006,000.

NO. 11.—LETTER FROM R. A. ALGER AND M. S. SMITH FAVORING A BRIDGE.

DETROIT, MICH., *November* 17, 1879.

GENTLEMEN: We are engaged in the long timber business, which is getting out long pine timber, making it into rafts on Lake Huron, and towing it principally to Toledo, Cleveland, and Tonawanda.

During the season of 1879 we have towed of our own timber over 40,000,000 feet, board measure, down through Detroit River, which is a large majority of all the long timber cut and rafted down through the lakes. Our rafts range in size from 1,000,000 to 2,000,000 feet. A raft of 1,000,000 feet would average about 1,800 feet long and 100 feet wide, and for each quarter of a million feet 25 feet in width may be added, at the outside, but nothing in length, as rafts are usually about the same length, and are enlarged by adding to the width. A good average raft contains about 1,500,000 feet. A raft containing 2,500,000 feet would measure 250 feet scant across it. This is an oversize raft, and larger than ought to be towed at one time.

While our business as shown above is large, it is our opinion that a bridge, with an opening of from 250 to 300 feet in a straight current like that in front of this city, would be no detriment to us, and with reasonable care exercised by the master of the tug towing rafts would not materially add to the risk and danger of towing.

This opinion is *entirely concurred in* by Capt. Thomas Hackett, master of our large tug Vulcan. Captain Hackett, who has sailed a tug for us for the past eleven years, and has towed over 200 rafts and a large number of vessels, entirely concurs in this opinion.

He says the difficulties and dangers of passing through a bridge in a straight current and deep water with tows of vessels would be very much less than that of entering the Saint Clair Flats Canal with its shallow water, and especially at the upper end where the current sets outside the canal both ways.

Believing that the business and welfare of the country need a bridge across the river at this point, and that with proper care exercised by masters of vessels such a bridge will not materally add to the dangers of navigation, we very respectfully and most earnestly ask you to report in favor of the project of building such a bridge.

Very respectfully,

R. A ALGER.
M. S. SMITH.

To the BOARD OF UNITED STATES ENGINEERS, *sitting at Detroit.*

NO. 12—LETTER OF JAMES M'MILLAN, CHAIRMAN CITIZENS' COMMITTEE, DETROIT, GIVING NUMBER OF PASSENGERS, PASSENGER AND BAGGAGE CARS, CROSSING AT DETROIT, FROM YEAR 1875 TO 1879.

DETROIT, MICH., *November* 19, 1879.

GENTLEMEN: Refering to a report made by the Citizens' Committee to your honorable Board on the 16th October, in the body of which the number of freight cars and tonnage for each year since 1875 inclusive was shown, permit me on behalf of said

committee to supplement the report above referred to with the following figures, having reference to the passenger business:

Years.	Passenger-cars.	Baggage-cars.	Passengers
1875	13,168	3,865	192,[illegible]
1876	13,565	4,683	209,630
1877	12,976	5,143	140,[illegible]
1878	12,258	3,873	129,113
1879	12,500	4,200	162,[illegible]

The above figures are official, having been furnished me by Mr. Broughton, general manager of the Great Western Railway.

Yours faithfully,

JAS. MCMILLAN,
Chairman Citizens' Committee.

To the BOARD OF UNITED STATES ENGINEERS,
In re proposed Detroit River Bridge.

No. 13.—ABSTRACT SHOWING NUMBER OF VESSELS PASSING WINDMILL POINT LIGHT-HOUSE, FORT GRATIOT LIGHT-HOUSE, AND THE SAINT CLAIR FLATS LOWER LIGHT.

OFFICE OF LIGHT-HOUSE INSPECTOR,
ELEVENTH DISTRICT.
Detroit, Mich., November 20, 1879.

DEAR SIR: As requested in your communication of this date, I inclose herewith a tabulated statement taken from the quarterly reports of the keeper of Windmill Point light, showing the number and kind of vessels passing that station during the years 1878 and 1879.

I would suggest that the reports of the keeper do not embrace all the vessels that pass that station, for there being only one keeper, he is not required to be always on watch, and many vessels no doubt pass that are not recorded.

As it may be of some service to your Board, I also inclose statements showing the vessels that passed the Fort Gratiot and Saint Clair Flats Canal (lower) lights during the year 1878, and from the opening of navigation to June 30, 1879.

The report of passing vessels is now made annually instead of quarterly as heretofore, so that for the latter stations, I have information only up to the date mentioned; but for Windmill Point a special report was made by the keeper up to November 1, 1879.

I consider the statement for Fort Gratiot light the most accurate, as there are two keepers at the station and both of them are sailors, who take an interest in keeping a correct record of the vessels that pass their light.

Very truly, yours,

J. N. MILLER,
Light-house Inspector, Eleventh District.

Lieut. Col. W. F. RAYNOLDS,
Brevet Brigadier-General, U. S. A.

OFFICE OF LIGHT-HOUSE INSPECTOR,
ELEVENTH DISTRICT,
Detroit, Mich., November 20, 1879.

Abstract from keeper's returns of vessels passing the Windmill Point light-station during the year 1878, and from the opening of navigation to November 1, 1879.

	Three-masted vessels.	Brigs.	Schooners.	Sloops.	Steamers.	Totals.
First quarter, 1878	1	....	76	19	76	172
Second quarter, 1878	928	2	1,758	223	2,260	5,171
Third quarter, 1878	871	....	1,942	178	2,597	5,588
Fourth quarter, 1878	468	....	1,081	77	1,641	3,267
Total for 1878	2,268	2	4,857	497	6,574	14,198
First quarter, 1879	....	....	....	....	....	....
Second quarter, 1879	396	....	1,865	124	2,241	4,626
Four months, 1879	729	1	4,240	260	4,901	10,131
Total for 1879	1,125	1	6,105	384	7,142	14,757

J. N. MILLER,
Commander, United States Navy, Inspector Eleventh District.

OFFICE OF LIGHT-HOUSE INSPECTOR,
ELEVENTH DISTRICT,
Detroit, Mich., November 20, 1879.

Abstract from keeper's returns of vessels passing Fort Gratiot light-station during the year 1878, and from the opening of navigation to June 30, 1879.

	Barges.	Barks.	Brigs.	Schooners.	Scows.	Steamers.	Totals.
First quarter, 1878	4	....	....	5	16	70	95
Second quarter, 1878	1,636	229	17	2,608	429	3,862	8,781
Third quarter, 1878	1,787	213	21	2,700	510	3,939	9,170
Fourth quarter, 1878	1,010	111	3	1,524	199	2,523	5,370
Total for 1878	4,437	553	41	6,837	1,154	10,394	23,416
First quarter, 1879	....	....	....	....	....	28	28
Second quarter, 1879	1,598	199	8	2,167	399	3,215	7,582
Total	1,598	199	8	2,167	399	3,243	7,610

J. N. MILLER,
Commander United States Navy, Inspector Eleventh District.

OFFICE OF LIGHT-HOUSE INSPECTOR,
ELEVENTH DISTRICT,
Detroit Mich., November 20, 1879.

Abstract from keeper's returns of vessels passing Saint Clair Flats Canal lower light-station during the year 1878, and from the opening of navigation to June 30, 1879.

	Three-masted vessels.	Schooners.	Steamers.	Total.
First quarter, 1878	......	6	41	47
Second quarter, 1878	17	2,114	1,804	3,935
Third quarter, 1878	28	2,700	1,960	4,688
Fourth quarter, 1878	20	1,863	1,474	3,357
Total for 1878	65	6,683	5,279	12,027
First quarter, 1879	......	......	......	......
Second quarter, 1879	30	2,192	1,943	4,165
Total	30	2,192	1,943	4,165

J. N. MILLER,
Commander United States Navy, Inspector Eleventh District.

NO. 14.—RESOLUTION OF THE BUFFALO BOARD OF TRADE AGAINST A BRIDGE.

BUFFALO BOARD OF TRADE,
Buffalo, N. Y., November 20, 1879.

At a meeting of members of the Buffalo Board of Trade held this morning on 'change, the president, Jewett M. Richmond, esq., in the chair, the following preamble and resolutions were offered by Townsend Davis, esq., and on motion unanimously adopted:

Whereas, the Board of Trade of the city of Buffalo learn that a commission, empowered by Congress, is now in session at Detroit for the purpose of determining whether a tunnel under the Detroit River, or a bridge across that stream, should be built; and whereas this Board regards the question as one of great importance to the commerce of the lakes and of the country; and whereas it is the opinion of this Board that the creation of a bridge across the river would be an obstruction to navigation, and in direct opposition to the principle of the great ordinance by which it was proposed forever to establish the freedom and promote the facilities of commerce upon the great waters of the Northwest, and in conflict with the substance of that decision of the Supreme Court of the United States declaring the international character of those waters, and as a practical question in conflict also with the best business intelligence of the country: Now, therefore, it is

Resolved, That in the opinion of this Board of Trade the bridging of the Detroit River at or near Detroit would be a great injury to commerce and leading business interests of the country; and this Board most earnestly requests the commission to report in the strongest terms against the erection of such bridge.

Correct extract from minute-book.

WILLIAM THURSTONE,
Secretary.

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BRIDGE ACROSS THE MISSISSIPPI RIVER AT FORT SNELLING, MINNESOTA.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Paul, Minn., March 3, 1880.

GENERAL: I have the honor to present the following report pertaining to the Fort Snelling Bridge, its completion and test. The act of Congress approved June 20, 1878, provides—

That the sum of sixty-five thousand dollars be, and the same is hereby, appropriated out of any money in the Treasury not otherwise appropriated, to aid in the construction and completion of a free wagon bridge, with stone abutments, or stone and iron abutments, and iron superstructure, across the Mississippi River at or near Fort Snelling, between the military reservation of the United States upon which said fort is situated and a point nearly opposite said fort in the county of Ramsey, Minnesota: *Provided*, That such bridge shall be constructed without the expenditure of any other or greater sum of money from the Treasury of the United States: *Provided also*, That the height of said bridge shall be at least 68 feet above high-water mark, and that a span of at least 200 feet in the clear be provided from the right or Fort Snelling bank of said river toward the left bank thereof: *Provided further*, That said bridge shall be and forever remain a public highway, free to the United States of America and to all the people thereof.

That the location of said bridge, and the plans, specifications, and estimates for the construction and completion thereof, shall be approved by the Secretary of War. And whenever the said bridge shall have been fully completed, as hereinbefore provided, opened to travel, and irrevokably dedicated as a public highway, free to the United States of America and all the people thereof, the Secretary of the Treasury shall pay to the persons entitled to receive the same by reason of the construction of said bridge, or to the commissioners authorized to build said bridge, the said sum of sixty-five thousand dollars, which sum is hereby appropriated for said purpose: *Provided*, That said bridge, when constructed, shall be kept in good order and repair by the county of Ramsey, Minnesota; and the United States shall never be liable to any expense in the maintenance or repair of said bridge.

That the commissioners authorized to build said bridge under a special act of the legislature of Minnesota, entitled "An act to authorize and provide for the construction of a free bridge across the Mississippi River at or near Fort Snelling, and to lay out suitable roads and approaches thereto," approved March second, eighteen hundred and seventy-six, and the acts amendatory thereof, and their successors, be, and they are hereby, authorized to abut said bridge upon the lands of the United States known as the Fort Snelling military reservation, and to construct and maintain an abutment thereon for said bridge, at such point as the Secretary of War shall approve, and to survey, locate, open, and maintain public roads or highways from said bridge, for which purpose a right of way not exceeding 100 feet in width, from said bridge, across said military reservation, upon such line or lines as the Secretary of War shall direct or approve, is hereby given and granted to said commissioners and their successors.

The commissioners, appointed by name, by an act of the legislature, chose Mr. J. S. Sewall as their engineer. He drew up, under the direction of the Board of Bridge Commissioners, a set of general specifications which were submitted to a Board composed of Brigadier-General Terry, commanding the Department of Dakota, and Major and Bvt. Maj. Gen. G. K. Warren, Corps of Engineers, who, from West Point, made, July 19, 1878, a report, approving, generally, the plans and specifications as submitted.

* * * * * * *

By letter of the Chief of Engineers, of the 27th of July, 1878, I was assigned to the general supervision, on the part of the government, of the construction of the bridge. Ground was broken for the bridge before I was able to visit the location.

* * * * * * *

Mr. Guy Wells, assistant engineer, was detailed from this office to inspect the bridge work to the extent of securing compliance with the

specifications. For the details of the work done as well as for an understanding of the differences that occurred from time to time, between the Board of Bridge Commissioners, their engineer, and myself, I would refer to my several letters to the department upon that subject and especially to my letter of January 6, 1879, accompanied by the plans of and calculations for the superstructure adopted by the Board of Commissioners.

The masonry work was finished by the 19th of June, 1879.

Specifications for the iron-work (the superstructure) and invitations to bid for the same, were issued in August, 1878, by the Board of Bridge Commissioners and their engineer, the 30th of September, 1878, being named as the day for opening the bids. The specifications drawn up by the bridge engineer, contained only general stipulations as to dimensions, quality of material, and factors of safety. Thirty-two bids in all were received. The Board of Bridge Commissioners awarded the contract to H. E. Horton & Co. Although the style of bridge (deck cantilever) was not what I would have chosen, I stated in my letter of the 6th of January, 1879, that the bridge, if built as indicated in the specifications and as delineated on the strain sheets, would be strong enough. The plan was approved of by the honorable Secretary of War. The original specifications (July 5, 1878) required;

> The iron superstructure to be so proportioned and constructed that, with a load of 1,800 pounds per linear foot upon the whole or any part thereof, there shall be no tensile strain upon any part of the structure exceeding 12,000 pounds per square inch, and no compressive strain exceeding one-fourth of the breaking weight of the part as calculated by Gordon's formula.

Gordon's formula, adapted to American practice (for wrought iron) is:

$$P = \frac{40000}{1 + \frac{l^2}{40000\, r^2}}$$

in which—

P = Strength per square inch in pounds;
l = Length in inches;
r = Least radius of gyration, in inches;

The specifications accompanying the advertisement of the engineer of the bridge (Mr. J. S. Sewall) stated the above as the formula to be observed in calculating strains of compression. This formula has various modifications; the last, and probably the most reliable, are those given in the "general specifications for a wrought-iron railway drawbridge to be erected for the Chicago, Milwaukee and Saint Paul Railway Company over canal in the city of Milwaukee 1879." They are—

For square column, flat ends .... $\left\{ \frac{38500}{1 + \frac{H^2}{5800}} \right.$

For square column, one pin end .... $\left\{ \frac{38500}{1 + \frac{H^2}{3000}} \right.$

For square column, two pin ends .... $\left\{ \frac{37800}{1 + \frac{H^2}{1900}} \right.$

For Phœnix column, flat ends .... $\left\{ \frac{42500}{1 + \frac{H^2}{4500}} \right.$

For Phœnix column, one pin end .... $\left\{ \dfrac{40000}{1+\dfrac{H^2}{2250}} \right.$

For Phœnix column, two pin ends .... $\left\{ \dfrac{36600}{1+\dfrac{H^2}{1500}} \right.$

For American column, flat ends .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{3750}} \right.$

For American column, one pin end .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{2250}} \right.$

For American column, two pin ends .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{1750}} \right.$

For common column, flat ends .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{2700}} \right.$

For common column, one pin end .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{1500}} \right.$

For common column, two pin ends .... $\left\{ \dfrac{36500}{1+\dfrac{H^2}{1200}} \right.$

The pin being so placed that the moment of inertia is, as near as practicable, equal on both sides of same; use formula for square column. The maximum strain permitted in any purely compressive member will be the quotient resulting from dividing the ultimate strength, as determined by the above formula, by a co-efficient of safety equal to $4+\frac{5H}{100}$, "H," as before, being the measure of length in terms of least diameter.

The specifications prepared by the bridge engineer provided for a wind force of 50 pounds per square foot of superstructure. The floor members, and other members supporting the load of one panel only, not to be strained to more than one-fifth of their breaking weight by a load (live) of 100 pounds per square foot. Sheaving strains upon pins or rivets not to exceed 8,000 pounds per square inch. All iron subjected to tension to have an elastic limit exceeding 25,000 pounds per square inch, and to be capable of bending short at least 90° without breaking.

The strain upon the outer fibers of the supporting pins, stated in terms of the areas of cross-section of the pins, was not touched upon in the specifications. The rule and formula for calculating this pin strain is a conventional one amongst engineers, and has only of late years, through the efforts of most distinguished bridge engineers, received proper attention. Specifications for bridges that required large factors of safety, for tensile strains, have so ignored pin strains as to admit of, for the tensile strain upon the outer fiber, as high as 50,000 to 60,000 pounds per square inch of cross-section of pin, while, at the same time, no tensile strains upon ties, &c., were allowed to exceed one-fifth of the breaking weight. Still, as the formula for deducting the sum of the bending moments upon a pin is conventional and very safe, engineers have, to date, allowed the theoretical tensile strain upon the outer fiber to exceed tensile strains upon other members by 50 per cent. In the case of the specifications for the Milwaukee draw-bridge, above referred to,

a specimen of highest American practice, the allowable strains upon tensile members are stated as follows:

For tensile strains in primary members of the truss, or those upon which the principal weight comes directly from the floor-beam	8,000 pounds per square inch,
For strains in secondary members, or those which receive their principal strains through the primaries	9,000 pounds per square inch,
Strains in tertiary members	10,000 pounds per square inch,
&c.	

And the strains on extreme fibers of pins, caused by bending, not to exceed 15,000 pounds per square inch, and, in determining this bending strain, the leverage distance to be considered as from center of eye-bar to center of bearing or of opposite eye-bar. The tensile strain on outer fiber is allowed to be 50 per cent. more than on the tie-bars, &c.

The contractors for the superstructure made their own bargains with the Keystone Bridge Company, of Pittsburgh, Pa., for the iron. Considering it as necessary to have the shop-tests superintended by some person in whose reports confidence could be placed, I informed the Board of Bridge Commissioners that such should be provided for. They requested me to nominate a person, to be paid by themselves. Colonel Merrill, to whom I applied, kindly named Mr. Charles Davis. He was accordingly employed by the Board of Bridge Commissioners. His reports are clear, satisfactory, and highly interesting. If time permits, I hope to be able to tabulate his and other inspection reports.

The contract between Horton & Co. and the Bridge Commissioners provided for the superstructure to be finished by September 1, 1879, and requiring a forfeiture of $25 per day for each and every day after that date that the completion of the superstructure was delayed.

From various causes the completion of the superstructure was delayed until the end of January, 1880. Occasionally a small lot of iron reached the ground; the advance in prices of iron following the increased demand for the same doubtless embarrassed the contractors somewhat. But the local press, the people, and the garrison at Fort Snelling demanded the early completion of the structure. Governed by these considerations, by the delay in finishing the work, and the almost daily report that the superstructure was about to be finished, and feeling the *grave* responsibility of certifying to the sum of $65,000 of public money; and, furthermore, expecting to be absent from Saint Paul more or less during the winter, I directed Assistants J. P. Frizell, Guy Wells, and C. J. A. Morris of my office to keep themselves fully informed as to the progress of the bridge, to test it when pronounced completed, to review at length the whole history of the bridge, and to make report thereon. I required a test live load to be placed upon the bridge of 1,800 pounds per linear foot. Ice was found to be the most convenient material with which to load the bridge. A cubic foot of ice weighs about 57.2 pounds. Ice, when corded up in blocks as for sale, is averaged at about 47 pounds per cubic foot. I was absent in Washington when the tests were made, but I had previously given specific instructions as to placing the rod. Mr. Charles Wanzer, assistant engineer, rendered efficient service in making the final tests.

It was agreed between the bridge engineer (Mr. Sewall) and myself that the deflection should not exceed the $\frac{1}{1000}$ part of the length of span.

The report of the board of assistants appointed by me, and the tracing of test sheet herewith, will fully explain the nature and extent of the tests which showed the bridge to be sufficiently "*stiff*." The wind-pres-

sure allowable was placed at 50 pounds per square foot (represented by wind velocity of 100 miles per hour). The highest velocity recorded at Saint Paul since the establishment here of the United States Signal Station is, I am told, a velocity affording about 13 pounds pressure per square foot. The common practice, in calculating for wind-pressure, is to regard the wind as passing between the web-members and acting with the same force upon the web-members upon the opposite truss. Where the web-members exposed flat surfaces the factor (50 pounds) was doubled.

Where the surfaces were curved (circular) the factor was not doubled. Where the wind would be fairly checked and not allowed to "pass through," 50 pounds was taken as the factor. The sum of the partial moments tending to overturn the structure was less than the moment of gravity, understanding by the latter term the product of the weight of the superstructure into one-half its width of base, or overturning moment, $<$ moment of gravity.

Calculations for the resistance of the superstructure to lateral motion (bodily) under wind-pressure were also made. The product of the weight by the coefficient of friction exceeded the lateral wind-pressure expressed in pounds. But to *insure safety*, a flange of wrought-iron was placed around the bed-plate on each main pier. And to insure, further, the safety of the three long spans, the ends of the 135 feet and 181½ feet spans have been anchored into the piers, and, furthermore, one of the sway-braces at each pier has been lengthened and anchored into the pier. In the case of a continuous structure, vibritions caused by blows or impact at any point are perceived, generally, throughout the length of the structure, and frequently erroneous notions as to its strength gain credence. Again, the 270 feet span, being supported solely by pins, may vibrate somewhat after the manner of a pendulum under heavy gusts of wind. But for vibration to exert its maximum effect the periods of vibration must coincide with the periods between impact.

The bridge is probably the strongest wagon bridge in this vicinity, although without merit as to architectural effect. It will withstand all but such extraordinary gales or hurricanes as defy engineering skill and which occasionally visit the Mississippi Valley. The final test was a severe one.

The report of the board of assistants appointed by me is forwarded herewith, as it contains a narrative of the work. I also forward a tracing showing the results of the tests made under my direction.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

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